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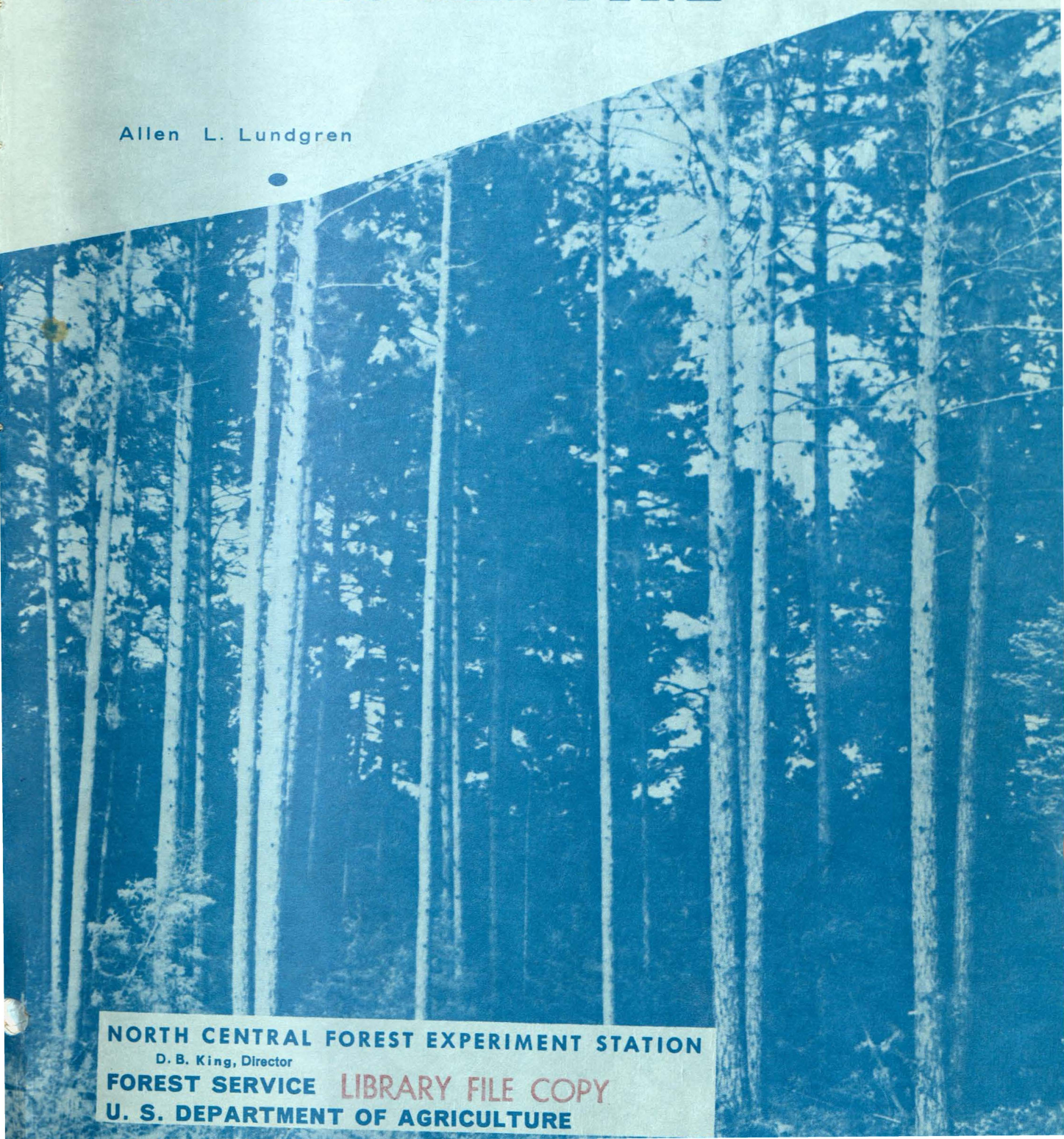
ESTIMATING INVESTMENT RETURNS from GROWING RED PINE

Allen L. Lundgren



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ESTIMATING INVESTMENT RETURNS FROM GROWING RED PINE

Allen L. Lundgren

I. INTRODUCTION

Red pine (*Pinus resinosa* Ait.) is a favored species in the Lake States. Every year landowners, including public agencies, invest large sums of money establishing and maintaining the growth of red pine stands for future timber production. They do this for many reasons: to earn an investment return by growing timber, to provide a reserve supply of timber, to protect hillsides from erosion, to beautify the landscape, to fill up empty space, or perhaps just because they want to grow trees.

Obviously, those who grow timber as an investment want to know what kind of return they can expect. But even landowners and managers who have other aims may wish to know the expected return on their investment if they should sell timber. Many will use this knowledge to decide whether they wish to grow red pine, some to decide how they should manage their stands, others to estimate how much they are losing by not selling timber or by favoring nontimber uses.

Fortunately, we know much about how red pine grows.[1] This information is useful in managing red pine to grow the kind of products owners want. But to solve many management problems we also must know how much it costs to grow timber under various conditions, and how much income can be expected in return. Such knowledge can be used to measure investment return and thus compare investment opportunities.

Note: The author, Dr. Lundgren, is Principal Economist on the staff of the North Central Forest Experiment Station. His headquarters are at the Station's Laboratories and Main Office, which are maintained by the Forest Service, U.S. Department of Agriculture, on the St. Paul Campus in cooperation with the University of Minnesota.

[1] *The reader who wants to find out more about red pine silviculture and management can start by reading Eyre and Zehngraff (1948), Rudolf (1957), and Buckman (1962) and referring to their list of references for additional reading. See "Literature Citations" at the back of this report for the list of literature referred to in this paper.*

Some appraisals of growing red pine as an investment have been made; a recent example is the work by Manthy et al. (1964). Although these studies answer some management questions, they consider only a few of the investment opportunities open to red pine timber growers and cover only a limited range of costs and prices. The results do not apply to many common investment situations.

This paper is designed to help timber owners and managers evaluate red pine timber-growing investments for a wide range of stand and site conditions, thinning practices, costs, future prices, and alternative discount rates. It presents tables of expectation value indexes and interest rate multipliers (tables 1 to 20 shown on blue sheets in the middle of the report) and explains how they can be used to answer many questions about the economics of growing red pine.

Not all readers may want to study every section of the report. Those who wish to understand the general principles involved and the methods used and assumptions made in developing the tables of expectation value indexes will find Sections II and III helpful.

Sections IV to VII explain how to use the tables to estimate incomes, costs, present net values, and rates of return, and give numerous examples of their use.

Sections VIII and IX show how to compare timber-growing alternatives and to determine the amount that can be spent for land and stand establishment and maintenance.

Section X will be useful to those interested only in the general level of returns for some common cost and price situations.

Although the paper was written primarily for the professional land manager, it contains only a minimum of technical terms so that others may find it useful also.

A large acreage in the Lake States once supported stands of pure, or nearly pure, red pine (above). Now much of this land grows aspen and other low-value hardwoods (bottom left). Where it is economically feasible, such land can be converted back to red pine. The photo at the bottom right shows both low-value hardwoods and successful conversion to red pine. The decision of whether to convert must be made by the forest landowner. But first he must investigate the cost of the venture and estimate the expected income — will his investments earn an acceptable rate of return?

If an acreage is to be converted, the unwanted forest cover must first be cleared away. This can be done by shearing and windrowing (above) at a cost of $30 to $40 per acre. Disking and other mechanical methods successfully prepare many areas for planting red pine and are often used, but the cost is also high. Such high expenses for site preparation, with the added costs of planting, are feasible only on the most productive forest land. Prescribed burning (right), where practical, may make it possible to clear large areas at a lower cost; this work must be done by trained personnel.

Once the pine stand is established, it may have to be released from competing vegetation; protected from fire, insects, and other destructive agents; and pruned and thinned to insure quality growth. These and other expenses often result in a large per-acre investment in timber-growing for long periods. Fortunately, in red pine stands thinning can be started at a young age to provide an early and continuous stream of income. Later thinnings and the final harvest will produce valuable saw logs. In some localities red pine can also be sold for posts, poles, pilings, and other products. The expected incomes, balanced against costs, determine the profitableness of growing red pine as an investment.

II. HOW INVESTMENT RETURNS ARE MEASURED

Investment returns from growing red pine will be measured in two ways: (1) by the expectation value, and (2) by the rate of return.

The expectation value of an investment is the net value at some point in time (usually the present) of expected future incomes and costs that have been discounted back to that time at some given rate of interest. This value is used to estimate the present or future net worth of an investment, or how much can be spent for land clearing, planting, pruning, or some other operation and still earn a specified rate of compound interest on invested capital. Expectation values or future net worths of different investment alternatives can be compared to pick out the most desirable program.

The rate of return is the compounded annual rate (usually given in percent) at which the value of invested capital increases over a period of time. By comparing earning rates among investments we can judge which investments offer the best chance for increasing invested capital.

Expectation values are closely related to rates of return, and both require the same information on costs and income. Each expresses the earning power of an investment in a different way. The choice of which measure to use will depend on what questions are to be answered.

In estimating the value of a timber-growing investment at some point in time, we must deal with the problem of time. Much of the investment may be made now, but it also may be necessary to invest more capital next year, still more the following year, and so on. Income may be deferred for years, and then be spread out over a long period. Where costs and incomes occur at different times, it is customary to discount or compound costs and incomes to some common point in time at a specified interest rate.[2]

The familiar compound interest formula is used to compound a value:

$$V_o\ (1+p)^n = V_n$$

Where: V_o is the value at investment age 0 to be compounded,

V_n is the value compounded for n years, and

p is the annual rate of compound interest.

Compound interest tables give the multiplier $(1+p)^n$ for various rates p and years n.

Discounting is done by rearranging the same basic formula to:

$$V_o = V_n \quad \frac{1}{(1+p)^n}$$

Most evaluations of investments are based on these simple formulas. Some of the more complex formulas are nothing more than shorthand ways of summarizing a series of simple compounding and discounting operations. To simplify computations, tables of the few special multipliers needed to evaluate red pine timber-growing investments are included in the blue section of this Paper.

The value of a timber-growing investment can be calculated for any age of a timber stand, but most of the time we want to know the expectation value at the time a stand is established. For this reason, all expected costs and incomes are usually discounted back to stand age zero.

The rate of interest to use in discounting is the alternative rate of return, the price of the capital to be invested. Since the rate used affects our estimates of investment return, it is important that this rate be realistic, one that would be earned on an investment we could and would undertake. For some investors this may be the rate that capital would earn if invested elsewhere within the organization, depending not only on what other investment opportunities are available, but also on how much capital there is to invest.[3] For other investors the alternative rate may be the interest paid on long-term government bonds or by savings institutions, currently about 4 percent. For still others it may be a rate that for one reason or another is considered satisfactory for timber-growing investments.

Since each investor has a different amount of investment capital and a different set of investment alternatives, it is not surprising to find many different rates being used to discount future incomes and costs. Therefore, in this Paper investment returns from growing red pine are shown for a range of rates.

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[2] *For an explanation of why compound interest calculations are used to evaluate investments see Davis (1954, Chapter 15) and Duerr (1960, Chapter 8).*

[3] *A more detailed explanation of how the alternative rate of return can be determined will be found in Duerr (1960, Chapter 10), Duerr et al. (1956, pp. 4-7), and Fedkiw (1960).*

III. THE BASIS FOR THE EXPECTATION VALUE INDEX TABLES

Before we can estimate incomes from selling timber we must first determine what kind and how much timber will be available for sale throughout a rotation under various conditions. Underlying the volume yield estimates in this Paper are the basal area growth predictions and net cubic-foot volume yields for red pine published by Buckman (1962). These data are for stands thinned to various basal area densities (60 to 150 square feet of basal area per acre) at 10-year intervals from ages 25 to 165 on site-index-45 to -60 land.

Because Buckman did not present data for all the types of stands to be considered, additional cubic-foot volume yield tables had to be constructed. Average diameters throughout the rotation were computed for each stand, using Buckman's basal area growth data. Cubic-foot yields were converted to cordwood yields at the rate of 9.7 cords per thousand cubic feet of total volume (this conversion factor was derived from Buckman's cordwood- and cubic-volume ratio estimates). To get board-foot yields, cubic-foot yields were multiplied by converting factors appropriate for the stand diameter and height. These factors were worked out from data given by Gevorkiantz and Olsen (1955).

One set of yield tables was developed for the volumes in cords available from thinning and from final harvesting at 10-year intervals from age 25 to 165. A similar set was made for the joint production of cordwood and sawtimber. An example of these latter tables is given in exhibit 1.

Altogether more than 500 volume yield tables, representing a range of sites, initial stand conditions, and thinning schedules, were constructed and evaluated; but most of the alternatives originally considered are not used in this analysis. For example, all thinning schedules that allow the basal area after thinning to vary throughout the rotation are omitted, because these seldom increased investment returns. Only two basal area densities left after thinning, 90 and 120 square feet per acre, are considered. Information about yields and growth rates of trees at densities below 90 square feet is incomplete; and leaving more than 120 square feet of basal area after thinning reduced investment returns for every situation evaluated (Lundgren 1965).

Because detailed growth data on stands less than 25 years old are not yet available, initial stand conditions are defined as the number of trees and basal area expected before thinning at age 25. For the number of trees in a stand at age 25 (800, 1,200, and 1,600 trees per acre are used here), investment returns are given for three basal area levels at that age. Until more information on

EXHIBIT 1. — Sawtimber and cordwood volume yields per acre from a thinned red pine stand on site index 55.[1]

Stand age (years)	Total height	Average d.b.h.	Volume cut if thinned		Volume cut if clearcut	
			Thousand		Thousand	
	Feet	Inches	bd. ft.	Cords	bd. ft.	Cords
25	27	5.2	0	3	0	13
35	39	6.7	0	9	0	23
45	50	8.4	0	10	0	28
55	59	10.3	4.7	2	14.3	5
65	66	12.3	5.4	0	17.8	1
75	72	14.5	5.8	0	20.9	0
85	78	16.7	5.9	0	23.2	0
95	82	19.0	5.8	0	25.6	0
105	86	21.3	5.4	0	26.7	0
115	90	23.5	-	-	27.7	0

1/ 800 trees and 120 square feet of basal area per acre before thinning at age 25; thinned every 10 years to 90 square feet of basal area per acre.

the growth of young stands is available, each forest manager will have to estimate as best he can how many trees and how much basal area he can expect at age 25 from a stand grown under his particular conditions. If he has no better information he may wish to use the middle level of basal area given here, which is probably a conservative estimate for fully stocked stands under average field conditions.

These volume tables were constructed with the following assumptions: All trees in the stand have the same diameter and total height as the average for the stand. All stands with an average diameter of less than 4.6 inches are nonmerchantable. All trees in stands averaging 4.6 inches or larger in diameter can be cut as cordwood. All trees in stands averaging 9.1 inches or larger in diameter are cut for saw logs where the market permits. Any cordwood yield shown jointly with sawtimber is from the tops of trees. Yields of less than 2 cords or 1,000 board feet per acre are nonmerchantable. Merchantable or not, the stand is thinned every 10 years to the indicated basal area. Nonmerchantable thinnings contribute nothing to net returns, but they can be carried out at no extra cost. No thinning will remove more than half the basal area of the stand.

These volume yields make no allowance for catastrophic losses such as those caused by fire or insect epidemics. Anyone applying these results to large areas may want to allow for the risk of loss from such causes.

The present value of timber sale incomes can be estimated by multiplying volume yields and stumpage prices to get the value yield at each age, and then discounting these values. Although correct, this process can be tedious if several evaluations are to be made, because each income must be discounted separately. Estimating the present value of timber sale income can be greatly simplified by using an *Expectation Value Index*.

To show how this index is derived, let's review how the present value of future incomes from timber sales is usually calculated.

Suppose, for example, that the following per-acre yields will be obtained in growing red pine:

Thinning at age 25	3 cords
Thinning at age 35	9 cords
Final harvest at age 45	28 cords

Multiplying each volume yield by a common stumpage price, (for example, $2 per cord), discounting each timber sale income back to age zero at the alternative rate (say 3 percent), and then adding the results together gives the *Present Value of Income* (PVI) from future timber sales in this stand:

$$\text{PVI} = 3(\$2)\frac{1}{(1.03)^{25}} + 9(\$2)\frac{1}{(1.03)^{35}} + 28(\$2)\frac{1}{(1.03)^{45}}$$
$$= \$6(.4776) + \$18(.3554) + \$56(.2644)$$
$$= \$24.06$$

To compute the present value for the same volume yields, but at a different price, the procedure is repeated. Obviously, much work is required to consider even a small range of stumpage prices.

Notice, however, that if the stumpage price is the same for each age we would get the same present value by first discounting the volumes, next adding them together, and then multiplying by the stumpage price:

$$\text{PVI} = \left[3\frac{1}{(1.03)^{25}} + 9\frac{1}{(1.03)^{35}} + 28\frac{1}{(1.03)^{45}}\right](\$2.00)$$
$$= \boxed{3}\,(.4776) + 9\,(.3554) + 28\,(.2644)\boxed{}\,(\$2.00)$$
$$= 12.03\,(\$2.00)$$
$$= \$24.06$$

If the *volumes* of a product are once discounted, then to consider a different stumpage price (say $3) all we have to do is multiply the sum of discounted volumes (12.03) by the new price to get a new present value ($36.09). The sum of discounted *volumes* is the Expectation Value Index (EVI). Although the method requires the use of constant stumpage prices, these prices can be at any level.

A separate EVI is needed for each product that is priced separately. Each index is multiplied by its own product price, and the resulting present values are added to get a total present value for all products. This approach could be used for any number of products, but here only cordwood and saw logs are considered.

The rotation age changes the timing and volumes of thinnings and final harvest cut, so the expectation value index is different for each rotation age. Fortunately, an EVI is needed only for the financial rotation age, the one giving the highest expectation value. This optimum financial rotation age varies with the discount rate used, but is not affected much by establishment and management costs and stumpage prices over a wide range. Even if an estimated rotation age misses the optimum by 10 or 20 years it will have little effect on estimates of investment return made at the beginning of the rotation (Lundgren 1965). Therefore, for these analyses one rotation age, based on establishment costs of $40 per acre with stumpage prices of $2 per cord and $20 per thousand board feet, can be set for each stand condition and discount rate. This rotation age, if not optimum, is close to it. On this basis, an EVI was com-

puted for the rotation age that would maximize present net values for a wide range of site indexes, stand conditions, and discount rates. These EVI's are presented in tables 1 to 16 in the center blue section.

Once the appropriate index has been located in the tables for a particular stand, all that is needed to estimate the present value of future timber sale income is to multiply each product index for that stand by the anticipated stumpage price. A suggested form for carrying out these simple computations is shown in a later section.

IV. ESTIMATING INCOME

When we invest capital in growing timber we expect to get back products or some other benefits in the future. Red pine trees can be sold for products such as posts, pulpwood, poles, piling, and saw logs, but we will consider only two: Pulpwood and saw logs sold as standing trees. Income from other products and benefits is provided by red pine forests, however, and if this income is known or can be estimated it should be included in an appraisal.

The Tables of Expectation Value Indexes

Timber sale incomes are estimated from the expectation value indexes discussed in the preceding section. Tables 1 to 16 (center blue section) provide 864 sets of EVI's and rotation ages for site indexes from 45 to 60 (later, we suggest how EVI's for lower or higher sites can be estimated), expected stand conditions before thinning at age 25 of 800 to 1,600 trees and 60 to 180 square feet of basal area per acre, and alternative rates from 2 to 8 percent. Indexes are given only for stands that are thinned back to the same basal area density level every 10 years throughout the rotation, but two densities are included, 90 and 120 square feet of basal area per acre. The 90-square-foot density is the one recommended for maximizing investment returns from growing red pine (Lundgren 1965), but including the 120-square-foot density offers the prospective investor a choice in computing investment return. The financial rotation is given in parentheses below each index.

To locate the desired table of indexes, the investor must:

1. Decide whether to grow red pine for both cordwood and saw logs, or for only cordwood;

2. Specify the basal area to be left after each thinning, either 90 or 120 square feet of basal area per acre;

3. Estimate the site index of the land, either 45, 50, 55, or 60 (from Gevorkiantz 1957).

Basal area after thinning	*Site index*	*See table no. —*
Cordwood and Sawtimber to be Sold		
90	45	1
90	50	2
90	55	3
90	60	4
120	45	5
120	50	6
120	55	7
120	60	8
Cordwood Only to be Sold		
90	45	9
90	50	10
90	55	11
90	60	12
120	45	13
120	50	14
120	55	15
120	60	16

For example, EVI's for growing both cordwood and sawtimber, thinning to 90 square feet on site index 55, are found in table 3.

Once the proper table has been found, the investor can locate the correct expectation value index and rotation age by:

4. Estimating the number of trees per acre expected before thinning at age 25, either 800, 1,200, or 1,600 trees.

5. Estimating the basal area per acre expected before thinning at age 25, either 60, 90, 120, 150, or 180 depending upon the site and number of trees.

6. Selecting the interest rate to be used in discounting incomes and costs.

In our previous example (using table 3), with 800 trees and 120 square feet at age 25 and a 3-percent interest rate, the index for cordwood is 7.59 and for sawtimber 4.38. The rotation age to be used with each set of indexes (95 years in this example) is enclosed in parentheses immediately below the index numbers.

Estimating Stumpage Prices

There is no way to know what the stumpage prices will be when timber is sold from stands now being established. All we can hope to do is to estimate what they will be. Because of this uncertainty, and also because of the difficulty of computing investment returns with complex price estimates, the following simple price estimates are used.

The price of cordwood and the price of sawtimber can be set at any level, but the price set applies to all future yields. For example, if the price of sawtimber is set at $24 per thousand board feet, then all future board-foot yields are valued at that price. If desired, average current prices can be used as an estimate of future prices. By calculating expectation values for both a high and low price or for several price levels, a range of future prices can be considered. In the examples that follow, stumpage prices are assumed to be net of timber sale costs.

Although these simple price assumptions restrict the kind of future prices that can be considered, most investors willingly accept them for estimating investment returns.

Calculating Present Value of Future Income From Timber Sales

The following example illustrates how EVI's are used to estimate the present value of timber sale income from growing red pine.

Red pine is to be grown for cordwood and sawtimber on site-index-55 land. The stand is expected to have 800 trees and 120 square feet of basal area per acre before thinning at age 25, and will be thinned back to 90 square feet of basal area per acre every 10 years. The discount rate is 3 percent.

For these conditions the EVI is 7.59 for cordwood and 4.38 for sawtimber with a rotation age of 95 (table 3). If the expected stumpage prices are $3 per cord and $22 per thousand board feet for this stand, the present value of future income from one rotation is (per acre):

7.59 x $3	=	$22.77
4.38 x $22	=	96.36
Total	=	$119.13

That is all there is to estimating the present value of future income from growing one rotation of red pine under these conditions.

EVI's are given only for the stated sites, densities, numbers of trees and basal areas per acre at age 25, and discount rates. No stand is likely to have exactly all of the stated characteristics. If a stand falls within the range of data given but does not exactly fit the stated characteristics, the nearest given stand characteristics can be used.

Perhaps red pine is to be grown on site-index-57 land, thinned to 90 square feet of basal area per acre every 10 years, with an expected 900 trees and 130 square feet of basal area per acre before thinning at age 25. None of the tables exactly fits such a stand, but an EVI can be estimated using a site index of 55 with 800 trees and 120 square feet of basal area per acre at age 25 (from table 3):

	Discount rate	
	3 percent	*6 percent*
Cordwood	7.59	2.70
Sawtimber	4.38	.60

A more accurate estimate can be obtained by interpolating among the indexes given in the tables. This can be done by plotting the known indexes on a graph and then reading off the actual value for the stand, by arithmetic interpolation using proportions, or even by just estimating. Although a three-way interpolation among sites, numbers of trees, and initial basal areas is not simple, the rounding-off error may be large enough to make it worthwhile. In the example we have been using, the interpolated EVI's would be:

	Discount rate	
	3 percent	*6 percent*
Cordwood	8.10	2.90
Sawtimber	4.81	.68

Thus, by rounding off to the nearest values for which an index was available, EVI's for the 3-percent discount rate were underestimated by 6 percent for cordwood and 9 percent for sawtimber. The underestimate was slightly larger with the 6-percent discount rate.

Usually, in rounding off to the nearest value for which an EVI is available, reducing the site index will decrease EVI's, reducing the initial number of trees per acre will increase EVI's, and reducing the initial basal area will decrease EVI's. In the above example, a decrease in EVI's because site index and basal area were reduced was partly offset by an increase in EVI's because the number of trees was reduced. Under some conditions the rounding-off errors may reinforce each other and result in even larger errors; under other conditions they may cancel each other and result in no error.

The indexes presented in these tables cover the range of growth and yield data available from site index 45 to 60. Red pine stands have been and are being established on poorer sites and on better sites than these, but we do not have enough information to compute EVI's on such sites. Furthermore, we will have to depend upon plantations for these growth data, so are not likely to get this information about older stands for decades. In the meantime indexes can be projected from the present range of sites. To evaluate site indexes of less than 45 or more than 60, the expectation value indexes can be plotted over site index and the plotted line extended to perhaps site index 40 on the

low side and to site index 70 on the high side. Although we do not know how accurate these projections are because they go beyond the range of available growth and yield data, at least they are a reasonable estimate on which to base an evaluation of such sites. Until better yield information is available, they can be used with some confidence.

Calculating Present Value of Other Income

If income from sources other than timber sales is expected, it can be included in the investment appraisal. To get the present value of incomes, each single income received is discounted back to age zero. For annual incomes such as hunting leases or homesite rentals a special formula is used to calculate the present value for one rotation:

$$\text{Present value of annual income} = i\,\frac{(1+p)^n - 1}{p\,(1+p)^n}$$

where: i is the annual income
n is the rotation age
p is the discount rate

Adding the present values of these other incomes to the present value of timber sale incomes gives the total present value of incomes from a timber-growing investment. In a later section we will suggest a simple form for computing these values.

V. ESTIMATING COSTS

Investors in timber growing may have to buy land; build roads, bridges, and other improvements; prepare planting sites; plant, release, thin, protect, and prune trees; and prepare and administer sales. Private owners pay annual taxes; public owners pay fire protection costs. Both will have road maintenance and other administrative expenses to pay. Not every timber-grower will have all of these expenses, but all will have some costs in growing timber. Such costs can be thought of as investments, outlays that must be made to grow a certain kind of timber in a certain way.

The costs of growing red pine fall naturally into three groups, each of which is handled differently in evaluating investments: (1) land and permanent improvements, (2) stand establishment and improvement, and (3) annual expenses. Almost every owner or manager has a different set of costs, so any specified here probably would apply to only a few individuals. Instead, we will outline the kind of costs falling into each group and show how to handle each type of cost in evaluating investments.

Land and Permanent Improvements

Investments in land and in permanent improvements are not used up in growing one crop of trees, but retain their value for longer than one rotation. Some investors may have to buy land; to these the price paid is a cost, a permanent investment. Others already own land for growing timber, and the question arises, "Should these owners include land as a cost of investment?"

If the owner (perhaps a public agency) cannot dispose of land and has no alternative but to keep it, then such land need not be included as a cost of investment. Owners who could sell their land have an investment in land, an opportunity cost. This is the value of other income forgone by keeping money tied up in land. An estimate of this cost should be included in an investment appraisal.

Other permanent and nondepreciable investments in land are also included in this cost group.[4] These include earthwork betterments and other improvements that will last for more than one rotation with only maintenance to keep them in shape. Fences, temporary roads, buildings, and other improvements that are expected to last only for a limited time and that can be depreciated are included under the next major cost group.

Land and permanent improvement costs are valued at age 0, when the stand is established. The costs of future permanent improvements to the land are discounted to age 0 and added together to get the present value of land costs (L_0). Because these are permanent investments, the entire cost is not charged off to one rotation of timber. At the end of the rotation the value of the land and its permanent improvements is still left. If we use the present value of the land as an estimate of its value at the end of the rotation, then the land cost for one rotation is computed as follows:

$$\text{Present value of land costs for one rotation} = L_0 - \frac{L_0}{(1+p)^n}$$

$$= L_0 \left[\frac{(1+p)^n - 1}{(1+p)^n}\right]$$

Table 17 in the blue section of this paper gives multipliers for various interest rates p and years n.

Stand Establishment and Improvement

Stand establishment and improvement costs include the costs of preparing the site, planting or seeding (or special measures needed to insure

[4] *Williams (1964) discusses what expenditures for land and permanent improvements are nondepreciable under the federal income tax laws.*

natural regeneration), release, early thinnings, special protection, and pruning. These are the direct costs of growing one crop of timber. If actual expenses for supervising these and other cultural practices are known or can be reliably estimated, then they should be included. Also included here may be temporary land improvements not accounted for under land costs. Private owners eligible for subsidy payments on some establishment and improvement practices should include only their share of the cost.

One group of costs not specified in our examples is the cost of selling timber, including cruising, marking, and preparing and supervising sales. In our examples we assume that stumpage prices are net of timber sale costs. This is saying, in effect, that sale costs are a constant percent of total sales value. If preferred, the estimated cost of making each sale can be included with stand establishment and improvement costs; they are handled in the same way.

To get the present value of establishment and stand improvement costs, each cost at any age t (C_t) is discounted to the present, and all discounted costs are added together:[5]

Present value of establishment costs —

$$= \sum C_t \frac{1}{(1+p)^t}$$

where: $\sum$ is the Greek letter Sigma, standing for "sum."

Table 18 in the blue section of this paper, gives values of this discount multiplier for various interest rates p and years n. Space did not permit including discount multipliers for every single year throughout the rotation. Costs occurring in years not shown in the table can be discounted in two steps using the multipliers given. For example, a cost of $20 at age 18 to be discounted at 4 percent can first be discounted 3 years to get its value at age 15:

$20 x 0.8890 = $17.78

This value at age 15 can then be discounted 15 years at 4 percent to get its present value at age zero:

$17.78 x 0.5553 = $9.87

Thus, a future cost of $20 at age 18 discounted at 4 percent has a present value of $9.87. The discount multiplier for 18 years and 4 percent is:

0.8890 x 0.5553 = 0.4936
(3 years) (15 years) (18 years)

[5] *If the cost is at the time of establishment (C_0), then $t = 0$. If $t = 0$, the discount factor $\frac{1}{(1+p)^0}$ equals 1, so $C_0 \frac{1}{(1+p)^0} = C_0$.*

It is important to remember that the costs to be included here are for an established stand. Thus, for example, if a proportion of the area planted each year is expected to fail, the planting cost per acre of established plantation is higher than the cost per acre planted. The cost per established acre is equal to the total planting costs divided by the number of acres actually established.

Annual Expenses

Property taxes and fire protection, road maintenance, and other general administration expenses often are lumped together and treated as one annual expense. Although changes in annual costs over a rotation can be considered, we will show only how to handle costs that are the same throughout the rotation.

The present value of annual costs for one rotation is computed, using the special discount multiplier shown in the following formula:

Present value of annual costs —

$$= c \frac{(1+p)^n - 1}{p(1+p)^n}$$

where: c is the annual cost.

Multipliers for various interest rates p and years n are given in table 19.

EXHIBIT 2. — Determining the present value of costs from growing one rotation of red pine.[1]

Age	Item	Cost	3-percent discount multiplier[2/]	Discounted value
0	Land	$10.00	0.9397	$ 9.40
0	Establishment	50.00	1.0000	50.00
3	Release	7.00	.9151	6.41
25	Pruning	20.00	.4776	9.55
-	Annual	.30	31.32	9.40
Present value of all costs (one rotation)				$84.76

1/ Rotation age 95 years, discount rate 3 percent.
2/ Discount multipliers:

Land = $\frac{(1.03)^{95}-1}{(1.03)^{95}}$ Table 17

Establishment = $\frac{1}{(1.03)^0}$ Table 18

Release = $\frac{1}{(1.03)^3}$ Table 18

Pruning = $\frac{1}{(1.03)^{25}}$ Table 18

Annual = $\frac{(1.03)^{95}-1}{.03\ (1.03)^{95}}$ Table 19

Summation of All Costs

Adding the present values of land, establishment, and annual costs gives the present value of all costs for one rotation. For example, take the per-acre costs of growing red pine, as shown in exhibit 2, for one 95-year rotation with a 3-percent discount rate. Each cost is multiplied by its appropriate discount multiplier. The sum of these discounted costs, $84.76, is the present value of all costs for one rotation.

VI. PRESENT NET VALUE AS A MEASURE OF INVESTMENT RETURN

An organized method of computing present values of incomes and costs, present net values, and land expectation values will save time and insure that some incomes or costs have not been overlooked. Exhibit 3 suggests an orderly way to work out these computations, and presents one example of the form in use. Let's follow it through, keeping in mind the more detailed discussion given earlier on how to compute present values of incomes and costs. In these computations we will use the tables of expectation value indexes to estimate present values of future timber sale income, and the tables of discount multipliers to calculate present values of other incomes and costs.

The heading of this form identifies the investment and lists the information needed to look up the expectation value indexes and discount multipliers. In this example, both cordwood and sawtimber are to be grown. The first step is to calculate the present values of timber sale incomes. Expectation value indexes for cordwood and saw timber for this stand (table 3) are entered in the appropriate space. The rotation age of 95 years, which is given in parentheses just below the indexes in table 3, is recorded in the heading for later use. Multiplying the index by the estimated stumpage price for each product (in this example $2 per cord and $20 per thousand board feet) gives the discounted income from timber sales (the present value of timber sale income).

Immediately below these computations are lines for entering other incomes if expected (none are shown in the example). Had an annual income from hunting leases, easements, or other sources been expected, it would have been entered and multiplied by the discount multiplier for a 95-year rotation and 3-percent interest rate from table 19 to get the discounted value. If other incomes had been expected at a particular age, such as from sales of Christmas trees or other products and uses, these would have been entered on the following lines. Multipliers for discounting such incomes are found in table 18.

Adding all of the discounted incomes from timber sales and other sources together gives the present value of all income from one rotation, in this example $102.78.

The next step is to compute the present value of costs. Each expected cost is entered as shown, and is then multiplied by the appropriate discount multiplier to get the discounted cost. Table 17 gives the land cost multiplier for a 95-year rotation and a 3-percent interest rate. The establishment cost is not discounted, of course, since it is for only one rotation. The release and pruning cost multipliers are from table 18, for 3 and 25 years, respectively, and a 3-percent interest rate. The multiplier for annual costs is from table 19 for a 95-year rotation and a 3-percent interest rate. Adding all the discounted costs together gives the present value of all costs for one rotation, $84.76 per acre in this illustration.

Subtracting the present value of costs from the present value of incomes gives a present net value for one rotation of $18.02.

If all costs and incomes are included in calculating the present net value of one rotation, then this value is a measure of what the entire investment is worth at the present time. If the value is positive, the present value of incomes is higher than the present value of costs. Such an investment provides not only enough income to pay the alternative rate (discount rate) on all invested capital but also additional income. The above investment, besides returning 3 percent compounded annually on all of the capital invested in the stand for one rotation, provides an extra income presently worth $18 per acre. By the end of the 95-year rotation this extra income, compounded at 3 percent, would amount to $298 per acre.

Besides answering many questions about a particular investment, the present net value for one rotation can be used to compare investments, but only if the rotation ages (investment periods) are the same. If rotation ages are not the same, the present net values must be adjusted to put them on a common time basis before a valid comparison can be made. This can be done by computing the land expectation value (LEV), which automatically adjusts all timber-growing investments, regardless of rotation length, to a common investment period.

To get the LEV, the present net value is multiplied by the factor $\frac{(1+p)^n}{(1+p)^n - 1}$, which assumes

EXHIBIT 3. — Suggested form for computing present values and land expectation values per acre of red pine. The example shown here is for a discount rate of 3 percent.

PRESENT-VALUE COMPUTING FORM FOR RED PINE STANDS

Site index 55. Thinned to 90 sq. ft. B.A. every 10 years. Expected stocking and stand density at age 25: 800 trees, 120 sq. ft. basal area per acre. Only cordwood to be grown ____. Both cordwood and sawtimber to be grown X.

Rotation age 95 1/ Discount rate 3 percent

INCOME CALCULATIONS

Timber sale income

	Expectation value index 1/	x	Stumpage price	=	Discounted income
Cordwood	7.59	x	$ 2.00	=	$ 15.18
Sawtimber	4.38	x	$ 20.00	=	$ 87.60

Other incomes

	Age	Income	x	Discount multiplier	=	
None	___	$	x	2/	=	$
	___	$	x	2/	=	$
Annual	xxx	$	x	3/	=	$

Present value of all income for one rotation-----$ 102.78

COST CALCULATIONS

Type of cost	Age	Cost	x	Discount multiplier	=	Discounted cost
Land	0	$ 10.00	x	.9397 4/	=	$ 9.40
Establishment	0	$ 50.00	x	1.0000	=	$ 50.00
Release	3	$ 7.00	x	.9151 2/	=	$ 6.41
Pruning	25	$ 20.00	x	.4776 2/	=	$ 9.55
Annual	xxx	$ .30	x	31.32 3/	=	$ 9.40

Present value of all costs for one rotation------$ 84.76

PRESENT NET VALUE FOR ONE ROTATION (discounted incomes minus costs)--- = $ 18.02

Land Expectation Value Multipliers 5/---------- x 1.0642

LAND EXPECTATION VALUE----------$ 19.18

1/ From tables 1 to 16.
2/ From table 18.
3/ From table 19.
4/ From table 17.
5/ From table 20.

that the value at the beginning of each future timber-growing investment after the first rotation will be the same as it is at present — in this example, $18.02. In the absence of more accurate information about future conditions, this seems a reasonable assumption. LEV multipliers for various rotation lengths (n) and interest rates (p) are given in table 20.

Because the LEV allows for the value of future investments after the first rotation, it is always larger than the present value from one rotation. In the previous example, with a 3-percent rate and 95-year rotation, the LEV is 6 percent larger:

EXHIBIT 4. — Suggested form for computing present values and land expectation values per acre of red pine. The example here is for a discount rate of 4 percent.

PRESENT-VALUE COMPUTING FORM FOR RED PINE STANDS

Site index 55. Thinned to 90 sq. ft. B.A. every 10 years. Expected stocking and stand density at age 25: 800 trees, 120 sq. ft. basal area per acre. Only cordwood to be grown ____. Both cordwood and sawtimber to be grown X.

Rotation age 85 1/ Discount rate 4 percent

INCOME CALCULATIONS

Timber sale income

	Expectation value index 1/	x	Stumpage price	=	Discounted income
Cordwood	5.31	x	$ 2.00	=	$10.62
Sawtimber	2.11	x	$ 20.00	=	$42.20

Other incomes

	Age	Income	x	Discount multiplier	=	
____	___	$____	x	2/	=	$____
____	___	$____	x	2/	=	$____
Annual	xxx	$____	x	3/	=	$____

Present value of all income for one rotation-----$ 52.82

COST CALCULATIONS

Type of cost

	Age	Cost	x	Discount multiplier	=	Discounted cost
Land	0	$ 10.00	x	.9643 4/	=	$ 9.64
Establishment	0	$ 50.00	x	1.0000	=	$50.00
Release	3	$ 7.00	x	.8890 2/	=	$ 6.22
Pruning	25	$ 20.00	x	.3751 2/	=	$ 7.50
Annual	xxx	$ .30	x	24.11 3/	=	$ 7.23

Present value of all costs for one rotation------$ 80.59

PRESENT NET VALUE FOR ONE ROTATION (discounted incomes minus costs)--- = $ -27.77

Land Expectation Value Multipliers 5/---------- x 1.0370

LAND EXPECTATION VALUE----------$ -28.80

1/ From tables 1 to 16.
2/ From table 18.
3/ From table 19.
4/ From table 17.
5/ From table 20.

Present net value (one rotation)	$18.02
LEV multiplier $\frac{(1.03)^{95}}{(1.03)^{95}-1}$	1.0642
Land expectation value	$19.18

This LEV is a measure of the return on the investment. It indicates that besides earning 3 percent on all invested capital, this investment also returns from all future rotations additional income with a present net value of $19.18 per acre. If each investment is the same amount, then the investment with the highest LEV also will earn the highest rate of return on invested capital.

Where discount rates are high and rotation ages are long, it may not be necessary to compute the

LEV because it differs so little from the present net value of one rotation. For example, with a 6-percent discount rate and a 125-year rotation, the LEV is only 0.1 percent larger than the present value of one rotation. At the other extreme, it may be desirable to compute the LEV where discount rates are low and rotation ages are short. With a 3-percent rate and a 45-year rotation the LEV is 36 percent higher, a sizable difference.

To illustrate how present values are calculated when costs exceed incomes, this same investment was evaluated using an interest rate of 4 percent rather than 3 percent (exhibit 4). Note that the 4-percent interest rate gives not only a new set of expectation value indexes but also a new rotation age, 85 instead of 95 years (table 3). With a change in interest rate and in rotation age a new set of discount multipliers is required. Using a 4-percent rate gives a present value of incomes of $52.82. Subtracting from this the present value of costs, $80.59, gives a negative present net value, −$27.77. A negative value indicates that the present value of costs exceeds that of incomes, and that the investment will not pay the alternative rate on the invested capital.

Although it takes a while to describe this procedure, once the stand characteristics and costs have been stated, the expectation value indexes and discount multipliers can be set down and the calculations made in only a few minutes, even if done by hand. With experience and the help of a desk calculator, the entire evaluation can be done in less than 5 minutes.

VII. RATE OF RETURN AS A MEASURE OF INVESTMENT RETURN

The rate of return (sometimes called the financial yield or internal rate of return) is the rate earned over an investment period on all the invested capital. It is the rate of interest that would make the sum of all compounded costs equal to the sum of all compounded incomes (or discounted costs equal to discounted incomes). Where there is only one initial investment, no other costs, and one final income, the rate of return is easily calculated.

Let C_o = initial investment at age 0

I_n = final income at age n

p = rate of return

Find p so that the compounded cost equals the final income:

$$C_o\,(1+p)^n = I_n$$

Expressed another way, find the rate of interest that makes the compound interest multiplier equal to the ratio of final income to initial investment:

$$(1+p)^n = \frac{I_n}{C_o}$$

If we could invest $100 now and get back $200 in 10 years, the rate of return p on this investment is found as follows:

$$(1+p)^{10} = \frac{\$200}{\$100}$$

$$(1+p)^{10} = 2.00$$

$$p = ?$$

We can solve for p directly by using logarithms, or we can approximate p from a table of compound interest rates. The log-log scales of a slide rule can also be used to solve for p to the nearest 100th of a percent. In the above example $p = 0.0717$, so the rate of return is 7.17 percent.

This simple technique for determining rate of return has many applications in forestry. For example, it can be used to determine the rate at which timber left after thinning increases in value; by comparing this rate with what could be earned elsewhere, we can decide whether to cut or to leave a stand. If we are growing pulpwood with only one final cut, this method can be used to estimate the rate of return on this investment.

Usually, however, forestry investments are much more complex than the example just given, and there are many costs and incomes during an investment period. If several costs or incomes occur throughout the rotation the rate of return can no longer be solved for directly, but it can be approximated graphically. To illustrate, the present values of incomes for one rotation were calculated for a red pine stand on site index 55 using a range of discount rates from 2 to 5 percent (exhibit 5). Only income from timber sales was considered. A rotation age of 105 maximized present net values for the 2-percent rate, 95 for the 3-percent, 85 for the 4-percent, and 75 for the 5-percent rate (table 3). For these same rates and rotation ages the present values of costs for one rotation were calculated, using the costs listed in exhibit 2.

Each present value of cost and income was plotted over the interest rate used to calculate it, and a cost curve and income curve were fitted to

Table 1 .--Expectation value index and rotation age for one rotation of red pine grown for cordwood and sawtimber jointly[1/]

Site index 45; thinned to 90 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Product	Discount rate (percent)					
		2	3	4	5	6	8
		800 TREES PER ACRE BEFORE THINNING AT AGE 25					
60	Cordwood	8.87	5.42	3.41	2.17	1.35	0.56
	Sawtimber	3.60	1.45	.63	.30	.15	.04
		(105)	(95)	(85)	(75)	(75)	(75)
90	Cordwood	9.11	5.88	3.84	2.61	1.79	0.81
	Sawtimber	4.92	2.09	.97	.48	.27	.08
		(105)	(95)	(85)	(75)	(65)	(65)
120	Cordwood	8.34	5.76	4.04	2.96	2.09	1.13
	Sawtimber	6.46	2.99	1.48	.78	.43	.15
		(95)	(85)	(85)	(65)	(65)	(55)
		1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	11.46	7.14	4.56	2.99	1.92	0.85
	Sawtimber	3.37	1.35	.58	.27	.14	.03
		(105)	(95)	(85)	(75)	(75)	(75)
120	Cordwood	9.48	6.06	3.99	2.67	1.84	0.82
	Sawtimber	4.63	1.97	.91	.45	.24	.07
		(105)	(95)	(85)	(75)	(65)	(65)
150	Cordwood	12.20	8.31	5.88	4.12	2.97	1.56
	Sawtimber	5.12	2.19	1.01	.51	.27	.08
		(105)	(95)	(75)	(75)	(65)	(65)
		1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	10.75	5.88	3.37	1.94	1.12	0.42
	Sawtimber	1.97	.72	.28	.11	.05	.01
		(105)	(105)	(95)	(95)	(95)	(95)
120	Cordwood	11.40	7.14	4.56	3.01	1.93	.85
	Sawtimber	3.36	1.35	.58	.27	.13	.03
		(105)	(95)	(85)	(75)	(75)	(75)
150	Cordwood	10.99	6.87	4.42	2.90	1.88	.84
	Sawtimber	3.76	1.51	.67	.32	.16	.04
		(105)	(95)	(85)	(75)	(75)	(75)

1/ Rotation ages are shown in parentheses.

Table 2 .--Expectation value index and rotation age for one rotation of red pine grown for cordwood and sawtimber jointly[1/]

Site index 50; thinned to 90 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Product	Discount rate (percent)					
		2	3	4	5	6	8
		800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	10.69	6.92	4.54	3.05	2.09	0.95
	Sawtimber	6.14	2.57	1.17	.57	.30	.09
		(105)	(95)	(85)	(75)	(65)	(65)
120	Cordwood	9.67	6.69	4.69	3.31	2.41	1.28
	Sawtimber	7.91	3.62	1.79	.93	.51	.18
		(95)	(85)	(85)	(75)	(65)	(55)
150	Cordwood	8.79	6.38	4.69	3.46	2.58	1.49
	Sawtimber	10.02	4.89	2.56	1.42	.82	.32
		(95)	(85)	(75)	(75)	(65)	(55)
		1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	13.10	8.18	5.32	3.40	2.25	.99
	Sawtimber	4.27	1.69	.72	.33	.16	.04
		(105)	(105)	(85)	(85)	(75)	(75)
120	Cordwood	10.83	6.99	4.58	3.11	2.13	.96
	Sawtimber	5.80	2.42	1.10	.54	.28	.08
		(105)	(95)	(85)	(75)	(65)	(65)
150	Cordwood	14.15	9.65	6.69	4.73	3.41	1.79
	Sawtimber	6.34	2.68	1.22	.61	.32	.09
		(105)	(95)	(85)	(75)	(65)	(65)
		1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	Cordwood	13.08	8.17	5.31	3.40	2.35	1.06
	Sawtimber	4.38	1.69	.72	.33	.15	.03
		(115)	(105)	(85)	(85)	(75)	(75)
150	Cordwood	11.17	7.16	4.70	3.14	2.07	.97
	Sawtimber	5.62	2.36	1.07	.52	.26	.08
		(105)	(95)	(85)	(75)	(75)	(65)
180	Cordwood	10.69	6.92	4.54	3.05	2.09	.95
	Sawtimber	6.10	2.57	1.17	.57	.30	.09
		(105)	(95)	(85)	(75)	(65)	(65)

1/ Rotation ages are shown in parentheses.

Table 3 .--Expectation value index and rotation age for one rotation of red pine grown for cordwood and sawtimber jointly[1/]

Site index 55; thinned to 90 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Product	Discount rate (percent)					
		2	3	4	5	6	8
		800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	12.37	8.00	5.23	3.47	2.39	1.08
	Sawtimber	7.39	3.12	1.39	.66	.35	.11
		(105)	(105)	(95)	(85)	(65)	(65)
120	Cordwood	10.97	7.59	5.31	3.75	2.70	1.45
	Sawtimber	9.73	4.38	2.11	1.09	.60	.21
		(105)	(95)	(85)	(75)	(65)	(55)
150	Cordwood	9.36	6.86	5.06	3.77	2.82	1.64
	Sawtimber	11.77	5.81	2.98	1.66	.96	.36
		(95)	(95)	(75)	(75)	(65)	(55)
		1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	15.18	9.48	6.00	3.90	2.59	1.14
	Sawtimber	5.42	2.07	.86	.38	.19	.05
		(115)	(105)	(95)	(85)	(75)	(75)
120	Cordwood	12.50	8.08	5.27	3.54	2.35	1.09
	Sawtimber	7.25	2.98	1.32	.63	.32	.10
		(115)	(105)	(95)	(75)	(75)	(65)
150	Cordwood	13.57	9.49	6.71	4.81	3.53	1.95
	Sawtimber	9.09	4.05	1.94	.99	.54	.18
		(105)	(95)	(85)	(75)	(65)	(55)
		1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	Cordwood	15.18	9.48	6.00	3.90	2.59	1.14
	Sawtimber	5.42	2.07	.86	.38	.19	.05
		(115)	(105)	(95)	(85)	(75)	(75)
150	Cordwood	12.59	8.12	5.29	3.57	2.37	1.10
	Sawtimber	7.06	2.89	1.28	.61	.31	.09
		(115)	(105)	(95)	(75)	(75)	(65)
180	Cordwood	12.37	8.00	5.23	3.47	2.39	1.08
	Sawtimber	7.38	3.12	1.39	.67	.35	.10
		(105)	(105)	(95)	(75)	(65)	(65)

1/ Rotation ages are shown in parentheses.

Table 4 .--Expectation value index and rotation age for one rotation of red pine grown for cordwood and sawtimber jointly[1/]

Site index 60; thinned to 90 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Product	Discount rate (percent)					
		2	3	4	5	6	8
		800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	11.37	7.57	5.08	3.44	2.34	1.20
	Sawtimber	10.71	4.67	2.21	1.11	.59	.20
		(115)	(105)	(95)	(85)	(75)	(55)
120	Cordwood	12.56	8.70	6.08	4.29	3.06	1.63
	Sawtimber	11.50	5.16	2.49	1.28	.69	.23
		(105)	(95)	(85)	(75)	(65)	(55)
150	Cordwood	10.74	7.89	5.82	4.33	3.24	1.88
	Sawtimber	13.89	6.88	3.55	1.94	1.12	.42
		(95)	(95)	(85)	(75)	(65)	(55)
		1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	Cordwood	14.47	9.37	6.12	4.05	2.71	1.26
	Sawtimber	8.75	3.58	1.59	.75	.38	.11
		(115)	(105)	(95)	(85)	(75)	(65)
150	Cordwood	15.22	10.72	7.62	5.48	4.03	2.23
	Sawtimber	11.10	4.82	2.30	1.17	.62	.21
		(115)	(95)	(85)	(85)	(65)	(55)
180	Cordwood	17.07	12.24	8.86	6.48	4.78	2.71
	Sawtimber	11.54	5.17	2.49	1.27	.69	.23
		(105)	(95)	(85)	(75)	(65)	(55)
		1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	Cordwood	15.26	9.78	6.33	4.16	2.86	1.30
	Sawtimber	8.02	3.16	1.38	.65	.31	.09
		(125)	(105)	(95)	(85)	(75)	(65)
150	Cordwood	14.55	9.41	6.15	4.06	2.72	1.27
	Sawtimber	8.61	3.50	1.55	.73	.36	.11
		(115)	(105)	(95)	(85)	(75)	(65)
180	Cordwood	11.37	7.57	5.08	3.44	2.34	1.20
	Sawtimber	10.68	4.66	2.20	1.10	.58	.19
		(115)	(105)	(95)	(85)	(75)	(55)

1/ Rotation ages are shown in parentheses.

Table 5 .--Expectation value index and rotation age for one rotation of red pine grown for cordwood and sawtimber jointly[1/]

Site index 45; thinned to 120 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Product	Discount rate (percent)					
		2	3	4	5	6	8
		800 TREES PER ACRE BEFORE THINNING AT AGE 25					
60	Cordwood	8.79	5.49	3.10	1.80	1.07	0.41
	Sawtimber	3.14	1.21	.53	.24	.11	.02
		(105)	(85)	(85)	(85)	(85)	(85)
90	Cordwood	10.43	5.92	3.76	2.30	1.42	0.58
	Sawtimber	3.86	1.66	.76	.37	.18	.05
		(95)	(85)	(75)	(75)	(75)	(75)
120	Cordwood	9.16	6.12	4.13	2.82	2.02	0.82
	Sawtimber	5.22	2.29	1.09	.57	.29	.09
		(95)	(85)	(75)	(65)	(65)	(65)
		1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	12.58	7.21	4.14	2.47	1.48	0.60
	Sawtimber	2.31	.87	.35	.14	.06	.01
		(105)	(95)	(95)	(95)	(95)	(95)
120	Cordwood	13.37	8.18	4.96	3.10	1.95	0.84
	Sawtimber	2.95	1.17	.51	.23	.10	.02
		(95)	(85)	(85)	(85)	(85)	(85)
150	Cordwood	12.98	8.50	5.68	3.76	2.62	1.21
	Sawtimber	3.95	1.66	.76	.37	.17	.05
		(95)	(85)	(75)	(75)	(75)	(75)
		1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	12.73	6.60	3.57	2.01	1.14	0.41
	Sawtimber	1.44	.47	.16	.05	.02	.00
		(115)	(115)	(115)	(115)	(115)	(115)
120	Cordwood	12.15	6.43	3.52	1.99	1.14	0.41
	Sawtimber	1.83	.66	.24	.09	.03	.01
		(105)	(105)	(105)	(105)	(105)	(105)
150	Cordwood	13.59	8.30	5.02	3.12	1.97	0.84
	Sawtimber	2.88	1.14	.50	.22	.10	.02
		(95)	(85)	(85)	(85)	(85)	(85)

1/ Rotation ages are shown in parentheses.

Table 6 .--Expectation value index and rotation age for one rotation of red pine grown for cordwood and sawtimber jointly[1/]

Site index 50; thinned to 120 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Product	Discount rate (percent)					
		2	3	4	5	6	8
		800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	10.89	6.93	4.40	2.71	1.70	0.70
	Sawtimber	4.97	1.95	.89	.43	.21	.05
		(105)	(85)	(75)	(75)	(75)	(75)
120	Cordwood	11.90	7.02	4.75	3.24	2.13	0.96
	Sawtimber	6.32	2.72	1.29	.66	.36	.11
		(105)	(85)	(75)	(65)	(65)	(65)
150	Cordwood	9.96	6.83	5.01	3.49	2.60	1.31
	Sawtimber	8.21	3.78	1.86	1.02	.60	.22
		(95)	(85)	(65)	(65)	(55)	(55)
		1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	13.60	8.01	4.86	2.92	1.79	0.73
	Sawtimber	3.34	1.27	.54	.24	.11	.02
		(105)	(95)	(85)	(85)	(85)	(85)
120	Cordwood	13.46	8.57	5.70	3.59	2.31	1.01
	Sawtimber	4.49	1.78	.78	.38	.19	.05
		(115)	(95)	(75)	(75)	(75)	(75)
150	Cordwood	14.74	9.75	6.53	4.32	2.93	1.39
	Sawtimber	5.00	2.00	.91	.44	.22	.06
		(105)	(85)	(75)	(75)	(75)	(75)
		1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	Cordwood	13.28	7.40	4.12	2.35	1.38	0.51
	Sawtimber	2.67	.99	.39	.16	.06	.01
		(105)	(95)	(95)	(95)	(95)	(95)
150	Cordwood	15.17	9.54	5.82	3.64	2.32	1.01
	Sawtimber	3.60	1.36	.60	.26	.12	.02
		(105)	(85)	(85)	(85)	(85)	(85)
180	Cordwood	13.60	8.56	5.57	3.52	2.28	1.00
	Sawtimber	4.55	1.87	.85	.41	.20	.05
		(95)	(85)	(75)	(75)	(75)	(75)

1/ Rotation ages are shown in parentheses.

Table 7.--Expectation value index and rotation age for one rotation of red pine grown for cordwood and sawtimber jointly[1/]

Site index 55; thinned to 120 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Product	Discount rate (percent)					
		2	3	4	5	6	8
		800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	10.74	6.87	4.47	2.83	1.75	0.76
	Sawtimber	7.03	2.89	1.35	.67	.38	.11
		(105)	(85)	(75)	(75)	(65)	(65)
120	Cordwood	12.45	8.05	5.37	3.70	2.45	1.10
	Sawtimber	7.65	3.17	1.49	.76	.41	.12
		(105)	(85)	(75)	(65)	(65)	(65)
150	Cordwood	11.14	7.69	5.36	3.92	2.92	1.48
	Sawtimber	9.62	4.39	2.17	1.16	.68	.24
		(95)	(85)	(75)	(65)	(55)	(55)
		1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	15.19	9.24	5.62	3.41	2.12	0.85
	Sawtimber	4.20	1.53	.64	.28	.13	.03
		(115)	(95)	(85)	(85)	(85)	(85)
120	Cordwood	15.59	9.79	6.25	4.12	2.66	1.15
	Sawtimber	5.47	2.10	.92	.44	.21	.05
		(115)	(95)	(85)	(75)	(75)	(75)
150	Cordwood	15.02	9.89	6.85	4.82	3.28	1.60
	Sawtimber	7.01	2.93	1.34	.67	.36	.11
		(105)	(95)	(75)	(65)	(65)	(65)
		1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	Cordwood	13.46	7.98	4.70	2.73	1.62	0.58
	Sawtimber	3.98	1.42	.58	.26	.11	.02
		(115)	(95)	(85)	(85)	(85)	(85)
150	Cordwood	15.76	9.93	6.34	4.17	2.68	1.16
	Sawtimber	5.27	2.02	.88	.41	.20	.05
		(115)	(95)	(85)	(75)	(75)	(75)
180	Cordwood	15.26	9.52	6.34	4.05	2.63	1.14
	Sawtimber	5.65	2.22	.97	.47	.23	.06
		(105)	(95)	(75)	(75)	(75)	(75)

1/ Rotation ages are shown in parentheses.

Table 8 .--Expectation value index and rotation age for one rotation of red pine grown for cordwood and sawtimber jointly[1/]

Site index 60; thinned to 120 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Product	Discount rate (percent)					
		2	3	4	5	6	8
		800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	Cordwood	12.40	7.80	5.13	3.27	2.24	0.96
	Sawtimber	8.57	3.46	1.56	.78	.41	.12
		(115)	(95)	(75)	(75)	(65)	(65)
120	Cordwood	11.42	7.58	5.13	3.60	2.66	1.22
	Sawtimber	10.79	4.65	2.23	1.16	.64	.23
		(115)	(95)	(75)	(65)	(55)	(55)
150	Cordwood	12.80	8.85	6.19	4.47	3.32	1.70
	Sawtimber	11.57	5.18	2.49	1.33	.75	.27
		(105)	(95)	(75)	(65)	(55)	(55)
		1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	Cordwood	17.75	11.06	7.12	4.68	3.03	1.33
	Sawtimber	6.56	2.50	1.05	.50	.24	.06
		(115)	(105)	(85)	(75)	(75)	(75)
150	Cordwood	17.19	11.36	7.81	5.48	3.75	1.84
	Sawtimber	8.52	3.44	1.53	.77	.41	.12
		(115)	(95)	(75)	(65)	(65)	(65)
180	Cordwood	15.93	11.10	7.88	5.78	4.36	2.28
	Sawtimber	10.53	4.65	2.22	1.17	.64	.23
		(105)	(95)	(75)	(65)	(55)	(55)
		1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	Cordwood	15.50	8.79	5.33	3.10	1.83	0.67
	Sawtimber	4.95	1.73	.68	.30	.14	.03
		(125)	(105)	(85)	(85)	(85)	(85)
150	Cordwood	18.06	11.20	7.21	4.74	3.05	1.33
	Sawtimber	6.32	2.38	1.01	.47	.23	.06
		(115)	(95)	(85)	(75)	(75)	(75)
180	Cordwood	15.16	9.69	6.35	4.24	2.93	1.31
	Sawtimber	8.13	3.27	1.47	.72	.38	.11
		(115)	(95)	(85)	(75)	(65)	(65)

1/ Rotation ages are shown in parentheses.

Table 9 .--Expectation value index and rotation age for one rotation of red pine grown for cordwood only[1/]

Site index 45; thinned to 90 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Discount rate (percent)					
	2	3	4	5	6	8
	800 TREES PER ACRE BEFORE THINNING AT AGE 25					
60	15.62 (95)	8.26 (85)	4.59 (85)	2.72 (75)	1.71 (65)	.74 (55)
90	17.50 (85)	9.75 (85)	5.74 (75)	3.48 (75)	2.26 (65)	1.02 (55)
120	19.08 (85)	10.99 (85)	6.72 (75)	4.35 (65)	2.86 (65)	1.40 (55)
	1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	17.50 (85)	9.75 (85)	5.74 (75)	3.48 (75)	2.26 (65)	1.02 (55)
120	17.50 (85)	9.75 (85)	5.74 (75)	3.48 (75)	2.26 (65)	1.02 (55)
150	20.72 (85)	12.25 (75)	7.73 (75)	5.15 (65)	3.50 (65)	1.79 (55)
	1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	14.30 (95)	7.48 (85)	4.12 (85)	2.32 (75)	1.43 (65)	.59 (55)
120	17.50 (85)	9.75 (85)	5.74 (75)	3.48 (75)	2.26 (65)	1.02 (55)
150	17.50 (85)	9.75 (85)	5.74 (75)	3.48 (75)	2.26 (65)	1.02 (55)

1/ Rotation ages are shown in parentheses.

Table 10.--Expectation value index and rotation age for one rotation of red pine grown for cordwood only[1/]

Site index 50; thinned to 90 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Discount rate (percent)					
	2	3	4	5	6	8
	800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	20.58 (85)	11.48 (85)	6.73 (75)	4.09 (75)	2.64 (65)	1.18 (55)
120	22.34 (85)	12.87 (85)	7.82 (75)	4.94 (75)	3.31 (65)	1.60 (55)
150	24.11 (85)	14.14 (75)	8.90 (75)	5.88 (65)	3.98 (65)	2.02 (55)
	1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	20.58 (85)	11.48 (85)	6.73 (75)	4.09 (75)	2.64 (65)	1.18 (55)
120	20.58 (85)	11.48 (85)	6.73 (75)	4.09 (75)	2.64 (65)	1.18 (55)
150	24.11 (85)	14.14 (75)	8.90 (75)	5.88 (65)	3.98 (65)	2.02 (55)
	1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	20.58 (85)	11.48 (85)	6.73 (75)	4.09 (75)	2.64 (65)	1.18 (55)
150	20.58 (85)	11.48 (85)	6.73 (75)	4.09 (75)	2.64 (65)	1.18 (55)
180	20.58 (85)	11.48 (85)	6.73 (75)	4.09 (75)	2.64 (65)	1.18 (55)

1/ Rotation ages are shown in parentheses.

Table 11.--Expectation value index and rotation age for one rotation of red pine grown for cordwood only[1/]

Site index 55; thinned to 90 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Discount rate (percent)					
	2	3	4	5	6	8
	800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	24.66 (95)	13.42 (85)	7.80 (85)	4.77 (75)	3.06 (65)	1.36 (55)
120	26.60 (95)	14.94 (85)	9.04 (75)	5.72 (75)	3.81 (65)	1.84 (55)
150	27.88 (85)	16.48 (85)	10.24 (75)	6.74 (65)	4.56 (65)	2.30 (55)
	1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	24.66 (95)	13.42 (85)	7.80 (85)	4.77 (75)	3.06 (65)	1.36 (55)
120	24.66 (95)	13.42 (85)	7.80 (85)	4.77 (75)	3.06 (65)	1.36 (55)
150	27.88 (85)	16.48 (85)	10.24 (75)	6.74 (65)	4.56 (65)	2.30 (55)
	1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	24.66 (95)	13.42 (85)	7.80 (85)	4.77 (75)	3.06 (65)	1.36 (55)
150	24.66 (95)	13.42 (85)	7.80 (85)	4.77 (75)	3.06 (65)	1.36 (55)
180	24.66 (95)	13.42 (85)	7.80 (85)	4.77 (75)	3.06 (65)	1.36 (55)

1/ Rotation ages are shown in parentheses.

Table 12.--Expectation value index and rotation age for one rotation of red pine grown for cordwood only[1/]

Site index 60; thinned to 90 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Discount rate (percent)					
	2	3	4	5	6	8
	800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	28.71 (95)	15.58 (85)	9.06 (85)	5.52 (75)	3.53 (65)	1.56 (55)
120	30.90 (95)	17.30 (85)	10.42 (75)	6.59 (75)	4.37 (65)	2.09 (55)
150	32.20 (85)	19.02 (85)	11.76 (75)	7.70 (65)	5.21 (65)	2.62 (55)
	1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	28.71 (95)	15.58 (85)	9.06 (85)	5.52 (75)	3.53 (65)	1.56 (55)
150	32.20 (85)	19.02 (85)	11.76 (75)	7.70 (65)	5.21 (65)	2.62 (55)
180	34.35 (85)	20.79 (85)	13.15 (75)	8.74 (65)	6.07 (65)	3.15 (55)
	1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	28.71 (95)	15.58 (85)	9.06 (85)	5.52 (75)	3.53 (65)	1.56 (55)
150	28.71 (95)	15.58 (85)	9.06 (85)	5.52 (75)	3.53 (65)	1.56 (55)
180	28.71 (95)	15.58 (85)	9.06 (85)	5.52 (75)	3.53 (65)	1.56 (55)

1/ Rotation ages are shown in parentheses.

Table 13.--Expectation value index and rotation age for one rotation of red pine grown for cordwood only[1/]

Site index 45; thinned to 120 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Discount rate (percent)					
	2	3	4	5	6	8
	800 TREES PER ACRE BEFORE THINNING AT AGE 25					
60	14.90 (85)	7.74 (75)	4.40 (65)	2.55 (65)	1.68 (55)	0.83 (45)
90	17.11 (85)	9.17 (75)	5.34 (65)	3.17 (65)	2.09 (55)	1.01 (45)
120	18.61 (75)	10.52 (75)	6.30 (65)	4.04 (55)	2.59 (55)	1.27 (45)
	1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	17.11 (85)	9.17 (75)	5.34 (65)	3.17 (65)	2.09 (55)	1.01 (45)
120	18.61 (75)	10.52 (75)	6.30 (65)	4.04 (55)	2.59 (55)	1.27 (45)
150	20.25 (75)	11.78 (65)	7.31 (65)	4.83 (55)	3.22 (55)	1.66 (45)
	1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	15.81 (85)	8.25 (75)	4.68 (65)	2.70 (65)	1.75 (55)	0.83 (45)
120	15.81 (85)	8.25 (75)	4.68 (65)	2.70 (65)	1.75 (55)	0.83 (45)
150	18.61 (75)	10.52 (75)	6.30 (65)	4.04 (55)	2.59 (55)	1.27 (45)

1/ Rotation ages are shown in parentheses.

Table 14.--Expectation value index and rotation age for one rotation of red pine grown for cordwood only[1/]

Site index 50; thinned to 120 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Discount rate (percent)					
	2	3	4	5	6	8
	800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	20.09 (85)	10.73 (75)	6.20 (65)	3.69 (65)	2.42 (55)	1.16 (45)
120	22.24 (85)	12.26 (75)	7.29 (65)	4.65 (55)	2.98 (55)	1.45 (45)
150	23.39 (75)	13.65 (75)	8.38 (65)	5.50 (55)	3.66 (55)	1.87 (45)
	1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	20.09 (85)	10.73 (75)	6.20 (65)	3.69 (65)	2.42 (55)	1.16 (45)
120	22.24 (85)	12.26 (75)	7.29 (65)	4.65 (55)	2.98 (55)	1.45 (45)
150	23.39 (75)	13.65 (75)	8.38 (65)	5.50 (55)	3.66 (55)	1.87 (45)
	1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	18.49 (85)	9.59 (75)	5.39 (65)	3.29 (65)	2.00 (55)	0.94 (45)
150	22.24 (85)	12.26 (75)	7.29 (65)	4.65 (55)	2.98 (55)	1.45 (45)
180	22.24 (85)	12.26 (75)	7.29 (65)	4.65 (55)	2.98 (55)	1.45 (45)

1/ Rotation ages are shown in parentheses.

Table 15.--Expectation value index and rotation age for one rotation of red pine grown for cordwood only[1/]

Site index 55; thinned to 120 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Discount rate (percent)					
	2	3	4	5	6	8
	800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	23.47 (85)	12.54 (75)	7.25 (65)	4.50 (55)	2.83 (55)	1.34 (45)
120	25.72 (85)	14.14 (75)	8.39 (65)	5.32 (55)	3.42 (55)	1.64 (45)
150	26.81 (75)	15.43 (65)	9.59 (65)	6.26 (55)	4.16 (55)	2.11 (45)
	1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	23.47 (85)	12.54 (75)	7.25 (65)	4.50 (55)	2.83 (55)	1.34 (45)
120	25.72 (85)	14.14 (75)	8.39 (65)	5.32 (55)	3.42 (55)	1.64 (45)
150	26.81 (75)	15.43 (65)	9.59 (65)	6.26 (55)	4.16 (55)	2.11 (45)
	1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	21.37 (85)	11.05 (75)	6.19 (65)	3.74 (55)	2.29 (55)	1.05 (45)
150	25.72 (85)	14.14 (75)	8.39 (65)	5.32 (55)	3.42 (55)	1.64 (45)
180	25.72 (85)	14.14 (75)	8.39 (65)	5.32 (55)	3.42 (55)	1.64 (45)

1/ Rotation ages are shown in parentheses.

Table 16.--Expectation value index and rotation age for one rotation of red pine grown for cordwood only[1/]

Site index 60; thinned to 120 square feet of basal area per acre every 10 years

Basal area per acre before thinning at age 25 (sq. ft.)	Discount rate (percent)					
	2	3	4	5	6	8
	800 TREES PER ACRE BEFORE THINNING AT AGE 25					
90	27.85 (95)	14.47 (75)	8.33 (65)	5.00 (65)	3.24 (55)	1.51 (45)
120	29.64 (85)	16.24 (75)	9.60 (65)	6.04 (55)	3.89 (55)	1.85 (45)
150	31.83 (85)	17.96 (75)	10.95 (65)	7.10 (55)	4.73 (55)	2.38 (45)
	1200 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	29.64 (85)	16.24 (75)	9.60 (65)	6.04 (55)	3.89 (55)	1.85 (45)
150	31.83 (85)	17.96 (75)	10.95 (65)	7.10 (55)	4.73 (55)	2.38 (45)
180	34.09 (85)	19.73 (75)	12.34 (65)	8.20 (55)	5.59 (55)	2.92 (45)
	1600 TREES PER ACRE BEFORE THINNING AT AGE 25					
120	24.59 (95)	12.65 (75)	7.04 (65)	4.21 (65)	2.58 (55)	1.17 (45)
150	29.64 (85)	16.24 (75)	9.60 (65)	6.04 (55)	3.89 (55)	1.85 (45)
180	29.64 (85)	16.24 (75)	9.60 (65)	6.04 (55)	3.89 (55)	1.85 (45)

1/ Rotation ages are shown in parentheses.

Table 17.--Land cost discount multipliers 1/

n Rotation length (years)	p = Interest rate (percent)						
	2	3	4	5	6	7	8
25	0.3905	0.5224	0.6249	0.7047	0.7670	0.8157	0.8540
35	.5000	.6446	.7466	.8187	.8699	.9063	.9324
45	.5898	.7356	.8288	.8887	.9274	.9524	.9687
55	.6635	.8032	.8843	.9317	.9594	.9758	.9855
65	.7239	.8536	.9219	.9580	.9773	.9877	.9933
75	.7735	.8910	.9472	.9742	.9873	.9937	.9969
85	.8142	.9189	.9643	.9842	.9929	.9968	.9986
95	.8476	.9397	.9759	.9903	.9961	.9984	.9993
105	.8750	.9551	.9837	.9940	.9978	.9992	.9997
115	.8974	.9666	.9890	.9963	.9988	.9996	.9999
125	.9159	.9751	.9926	.9977	.9993	.9998	.9999
135	.9310	.9815	.9950	.9986	.9996	.9999	1.0000
145	.9434	.9862	.9966	.9991	.9998	.9999	1.0000
155	.9535	.9898	.9977	.9995	.9999	1.0000	1.0000
165	.9619	.9924	.9984	.9997	.9999	1.0000	1.0000

1/ $\frac{(1+p)^n - 1}{(1+p)^n}$. To determine the present value for one rotation of land and permanent improvement costs.

Table 18.--Future income and cost discount multipliers [1/]

t (years)	p = Interest rate (percent)						
	2	3	4	5	6	7	8
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	.9804	.9709	.9615	.9524	.9434	.9346	.9259
2	.9612	.9426	.9246	.9070	.8900	.8734	.8573
3	.9423	.9151	.8890	.8638	.8396	.8163	.7938
4	.9238	.8885	.8548	.8227	.7921	.7629	.7350
5	.9057	.8626	.8219	.7835	.7473	.7130	.6806
6	.8880	.8375	.7903	.7462	.7050	.6663	.6302
7	.8706	.8131	.7599	.7107	.6651	.6228	.5835
8	.8535	.7894	.7307	.6768	.6274	.5820	.5403
9	.8368	.7664	.7026	.6446	.5919	.5439	.5002
10	.8204	.7441	.6756	.6139	.5584	.5084	.4632
15	.7430	.6419	.5553	.4810	.4173	.3624	.3152
20	.6730	.5537	.4564	.3769	.3118	.2584	.2146
25	.6095	.4776	.3751	.2953	.2330	.1842	.1460
35	.5000	.3554	.2534	.1813	.1301	.0937	.0676
45	.4102	.2644	.1712	.1113	.0726	.0476	.0313
55	.3365	.1968	.1157	.0683	.0406	.0242	.0145
65	.2760	.1464	.0781	.0420	.0226	.0123	.0067
75	.2265	.1090	.0528	.0258	.0126	.0062	.0031
85	.1858	.0811	.0357	.0158	.0071	.0032	.0014
95	.1524	.0603	.0241	.0097	.0039	.0016	.0007
105	.1250	.0449	.0163	.0060	.0022	.0008	.0003
115	.1026	.0334	.0110	.0037	.0012	.0004	.0001
125	.0841	.0248	.0074	.0022	.0007	.0002	.0001
135	.0690	.0185	.0050	.0014	.0004	.0001	.0000
145	.0566	.0138	.0034	.0008	.0002	.0001	.0000
155	.0464	.0102	.0023	.0005	.0001	.0000	.0000
165	.0381	.0076	.0016	.0003	.0001	.0000	.0000

1/ $\frac{1}{(1+p)^t}$. For discounting future incomes or costs to the present.

Table 19.--Annual income and cost discount multipliers [1/]

n Rotation length (years)	p = Interest rate (percent)						
	2	3	4	5	6	7	8
25	19.52	17.41	15.62	14.09	12.78	11.65	10.68
35	25.00	21.49	18.66	16.37	14.50	12.95	11.66
45	29.49	24.52	20.72	17.77	15.46	13.61	12.11
55	33.18	26.77	22.11	18.63	15.99	13.94	12.32
65	36.20	28.45	23.05	19.16	16.29	14.11	12.42
75	38.68	29.70	23.68	19.48	16.46	14.20	12.46
85	40.71	30.63	24.11	19.68	16.55	14.24	12.48
95	42.38	31.32	24.40	19.81	16.60	14.26	12.49
105	43.75	31.84	24.59	19.88	16.63	14.27	12.50
115	44.87	32.22	24.73	19.93	16.65	14.28	12.50
125	45.80	32.50	24.82	19.95	16.66	14.28	12.50
135	46.55	32.72	24.88	19.97	16.66	14.28	12.50
145	47.17	32.87	24.92	19.98	16.66	14.28	12.50
155	47.68	32.99	24.94	19.99	16.67	14.29	12.50
165	48.10	33.08	24.96	19.99	16.67	14.29	12.50

1/ $\frac{(1+p)^n - 1}{p(1+p)^n}$. To determine the present value for one rotation of annual incomes or costs.

Table 20.--Land expectation value multipliers [1/]

n Rotation length (years)	p = Interest rate (percent)						
	2	3	4	5	6	7	8
25	2.5610	1.9143	1.6003	1.4190	1.3038	1.2259	1.1710
35	2.0001	1.5513	1.3394	1.2214	1.1496	1.1033	1.0725
45	1.6955	1.3595	1.2066	1.1252	1.0783	1.0500	1.0323
55	1.5072	1.2450	1.1308	1.0733	1.0423	1.0248	1.0147
65	1.3813	1.1715	1.0848	1.0438	1.0232	1.0125	1.0068
75	1.2928	1.1223	1.0557	1.0264	1.0128	1.0063	1.0031
85	1.2282	1.0882	1.0370	1.0161	1.0071	1.0032	1.0014
95	1.1798	1.0642	1.0247	1.0098	1.0040	1.0016	1.0007
105	1.1429	1.0470	1.0165	1.0060	1.0022	1.0008	1.0003
115	1.1143	1.0346	1.0111	1.0037	1.0012	1.0004	1.0001
125	1.0919	1.0255	1.0075	1.0022	1.0007	1.0002	1.0001
135	1.0741	1.0188	1.0050	1.0014	1.0004	1.0001	1.0000
145	1.0600	1.0140	1.0034	1.0008	1.0002	1.0001	1.0000
155	1.0487	1.0103	1.0023	1.0005	1.0001	1.0000	1.0000
165	1.0396	1.0077	1.0016	1.0003	1.0001	1.0000	1.0000

[1/] $\frac{(1+p)^n}{(1+p)^n - 1}$. To change present net values for one rotation to land expectation values.

EXHIBIT 5. — Present values of incomes and costs for one rotation of red pine grown on site-index-55 land. [1]

Item	Discount rate (percent)			
	2	3	4	5
Rotation age	105	95	85	75
Present value of timber sale income	$216.50	$102.80	$52.80	$29.30
Present value of costs	90.60	84.80	80.60	77.50
Present net value	125.90	18.00	-27.80	-48.20

1/ At age 25, 800 trees and 120 square feet of basal area per acre before thinning; thinned every 10 years to 90 square feet of basal area per acre; stumpage prices $20 per thousand board feet, $2 per cord.

the plotted points (exhibit 6). Notice that at a 3-percent discount rate the present value of incomes exceeds that of costs; at 4 percent, costs exceed incomes; and at 3.3 percent the present value of costs equals the present value of incomes. Thus, the rate of return on this investment is 3.3 percent.

This is not the only way to find the rate of return graphically. Plotting either the present net value of one rotation or the land expectation value will give the same answer. The discount rate that makes either one equal to zero is the rate of return, in this case 3.3 percent. But using discounted costs and returns separately has some advantages.

For example, a simple inspection of the curves shows that the present value of costs is only slightly influenced by the discount rate. This is not unexpected, because a larger proportion of the cost (land, establishment, and release) occurs at the beginning of the investment. On the other hand, the present value of incomes is greatly affected by the discount rate because most incomes occur late in the investment period and are discounted over long periods.

These cost and income curves give other information about this investment. A comparison shows how much costs and incomes must be changed in order to earn a fixed rate of return on the investment. If costs are lowered by 34 percent, for example, from $81 to $53 present value at a 4-percent rate, or incomes are raised by 53 percent, this investment would return 4 percent. To get this income increase, sawtimber stumpage prices would have to be $31 per board foot rather than $20, and cordwood $3.10 per cord rather than $2.00.

Cost and income present value curves can also be useful in comparing investment opportunities as described in the next section.

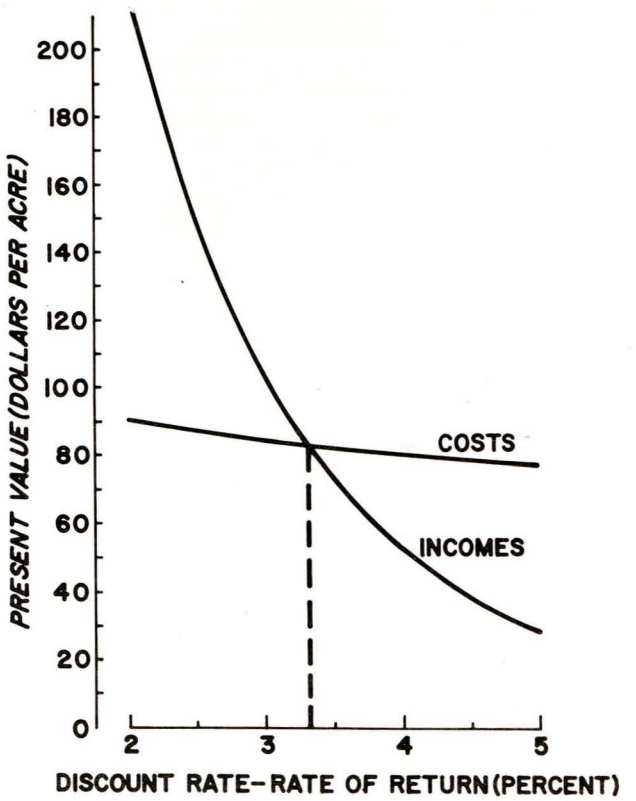

EXHIBIT 6. — Estimating rate of return graphically. The rate of return is the discount rate where the present values of costs and incomes for one rotation are equal.

VIII. COMPARING INVESTMENT OPPORTUNITIES

Knowing the present value of costs and incomes makes it possible not only to measure investment returns for a particular red pine timber-growing opportunity, but also to compare alternative investment opportunities. For example, suppose the alternative to investing in the site-index-55 example (exhibit 6) is investing in growing red pine on a lower site index of 45, with lower costs:

Costs	*Age*	*Cost per acre*
Land	0	$ 5.00
Establishment	0	40.00
Pruning	25	20.00
Annual	—	.30

By graphing the present values of costs and incomes for this stand (exhibit 7) and the site-index-55 stand (exhibit 5) in the manner shown in exhibit 8, several useful comparisons can be made.

First, the rates of return can be compared directly. Note that the better site, in spite of higher costs, gives a higher rate of return on invested capital than does the poor site — 3.3 percent compared to 2.8 percent. With these same curves it is possible to compare discounted costs and incomes directly for any discount rate. For example, with a 3-percent rate, discounted incomes are lower than costs by $10 on the poor site, so the present net value is negative. On the good site, discounted incomes are $18 higher than costs, so the present net value is positive. Looked at another way, if money had to be borrowed at 3-percent compound interest to pay for the investment costs, and all income went to pay off this debt, by

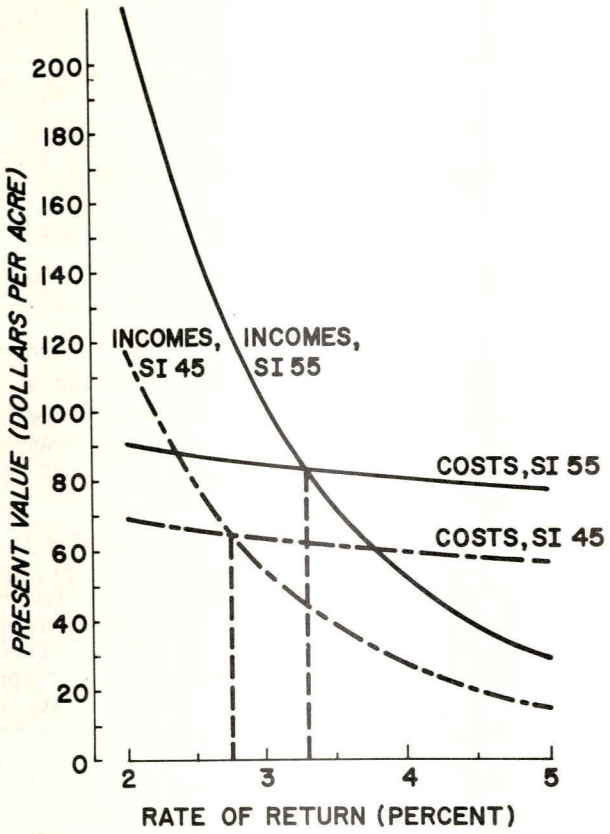

EXHIBIT 8. — Comparing investment returns on two sites.

EXHIBIT 7. — Present values of incomes and costs for one rotation of red pine grown on site-index-45 land. [1]

Item	Discount rate (percent)			
	2	3	4	5
Rotation age	105	95	85	75
Present value of timber sale incomes	$116.60	$53.60	$27.10	$14.80
Present value of costs	69.70	63.70	59.60	56.60
Present net value	46.90	-10.10	-32.50	-41.80

1/ At age 25, 800 trees and 90 square feet of basal area per acre before thinning; thinned every 10 years to 90 square feet of basal area per acre; stumpage prices $20 per thousand board feet, $2 per cord.

the end of a 95-year rotation the investor would still owe $167 per acre ($10.10 x $(1.03)^{95}$) on the poor site even after selling all the timber on the land. On the good site he would more than break even; after paying off the debt he would have $298 per acre left over.

Obviously, whether measured by rate of return or present value, the more productive site shows a higher investment return than the poorer site for the costs and stumpage prices shown here. Note that, because the rotation ages are the same for either investment alternative, it is not necessary to correct present values from one rotation with land expectation value multipliers to put them on a common time basis. Present values for one rotation of these two alternatives can be compared directly.

These cost and income curves also show how sensitive the rate of return is to changes in costs and stumpage prices. From them, we can estimate how much costs would have to change before the poor site would give a higher rate of return than the good site. If the present value of costs on site index 45 could be lowered from $62 to less than $44 per acre at an alternative rate of 3.3 percent, then the poor site would have a higher rate of return than the good site. In the same way, the changes in incomes necessary to make the two investment opportunities equal can be estimated from these curves. Comparisons such as these indicate the range of costs (or incomes) within which we can work before having to reconsider an investment decision.

Using this same technique, other investment opportunities such as initial stand conditions (the estimated number of trees and basal area per acre before thinning at age 25) can be compared to determine which opportunity will give the highest investment return. To illustrate, let's compare the previous example of a stand on site index 55 having an expected 800 trees and 120 square feet of basal area per acre at age 25 (exhibit 5) with a stand on the same site but having an expected 1,600 trees and 150 square feet (exhibit 9). The only difference in costs is an additional $20 per acre for planting enough trees to get 800 more trees per acre at age 25. Plotting the present values of incomes and costs over the discount rate (exhibit 10) shows that the 800-tree alternative not only gives higher incomes and lower costs at every discount rate, but a higher rate of return as well, 3.3 percent as compared to 2.5 percent for the 1,600-tree alternative. Correcting for infinite rotations with the land expectation value multiplier would result in an even greater advantage for the 800-tree alternative, although it would not change the rate of return.

By comparing these cost and income curves, it is possible to estimate how sensitive the choice of initial stocking is to costs. In order for 1,600 trees per acre to be as profitable as the 800 (returning 3.3 percent on invested capital), costs in the more heavily stocked stand would have to drop from a present value of $103 per acre to $58 while costs in the lightly stocked stand remain at $83. Because such a large decrease in costs is unlikely under any foreseeable circumstances, we would conclude that our choice of 800 trees rather than 1,600 trees is insensitive to costs.

The same technique can be used to compare other types of investment opportunities, such as the choice of density to be left after thinning, differential stumpage prices, or differences in land costs or other costs of production. However, these examples should be enough to show how such comparions can be made, given the present values of costs and incomes.

EXHIBIT 9. — Present values of incomes and costs for one rotation of red pine grown on site-index-55 land with high initial stocking. 1

Item	Discount rate (percent)			
	2	3	4	5
Rotation age	115	105	95	75
Present value of timber sale incomes	$166.40	$74.00	$36.20	$19.30
Present value of costs	111.20	105.00	100.80	97.50
Present net value	55.20	-31.00	-64.60	-78.20

1/ At age 25, 1,600 trees and 150 square feet of basal area per acre before thinning; thinned every 10 years to 90 square feet of basal area per acre; stumpage prices $20 per thousand board feet, $2 per cord.

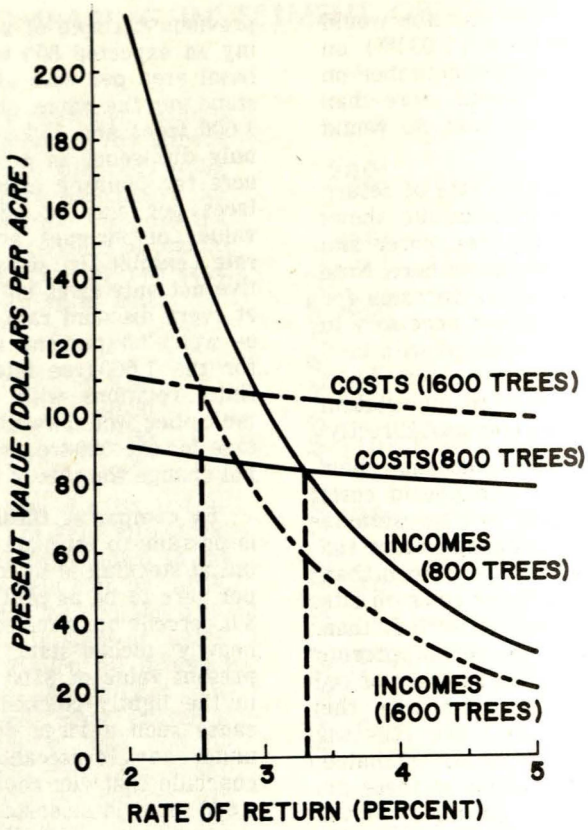

EXHIBIT 10. — Comparing investments for two initial stand conditions.

IX. ANSWERING OTHER QUESTIONS ABOUT INVESTMENTS

Present values of costs and incomes can be used also to answer other questions that investors ask about growing red pine: How much can I pay for land, stand establishment, or annual costs and still earn 4 percent (or some other specified rate) on my investment? How much will it cost per cord (or per thousand board feet) to grow red pine under my conditions?

Let's see how such questions can be answered for the red pine stand with the incomes and costs shown in exhibit 3. In this example the present value of incomes for one rotation was $102.78, and the present value of costs was $84.76 per acre. Had the present value of costs been higher by $18.02, costs would have equaled incomes and the investment would have just earned the discount rate, in this case 3 percent. The $102.78 present value of income is an estimate of how high costs can be under these conditions and still earn at least 3 percent, the discount rate, on invested capital. If the present value for one rotation of all known costs is subtracted from the present value of incomes, the balance is the present value of how much can be spent during one rotation for all other costs.

How Much Can Be Paid for Land?

Many potential timber growers buying land to grow trees would like to know the highest price they could pay for land of different kinds and at different locations and still earn a specified rate of investment return. By specifying the minimum rate of return they will accept, and estimating their expected incomes and costs (excluding the price of land), they can arrive at an estimated ceiling price for land.

In our example (exhibit 3), the present value of all costs excluding land was $84.76 less $9.40, or $75.36. With the same income value as before, the

present net value for one rotation without any land costs would be $102.78 minus $75.36, or $27.42. Under these conditions, land costs for one rotation could be as much as $27.42 per acre and the investment would still earn at least 3 percent. But at the end of one rotation the land and permanent improvements still have a value. How much, then, can be paid for land and permanent improvements?

The present value of land costs for one rotation —

$$= L_o \frac{(1+p)^n - 1}{(1+p)^n}$$

Where: L_o is the initial cost of land and permanent improvements,

p is the discount rate, and
n is the rotation age.

Setting this expression equal to $27.42 and solving for the initial land cost, L_o:

$$L_o \frac{(1.03)^{95} - 1}{(1.03)^{95}} = \$27.42$$

$$.9397\ L_o = \$27.42$$

$$L_o = \$29.18$$

Thus, for these costs and incomes we could spend up to $29 per acre for land and permanent improvements and still earn 3 percent on all invested capital. If land costs are less than this, the investment will earn more than 3 percent; if they are more, the investment will earn less than 3 percent.

Had 4 percent been used to discount costs and incomes over an 85-year rotation (exhibit 4), the present net value excluding land costs would have been —$18.13 per acre and the maximum land cost would have been —$18.80 per acre. This negative land cost indicates that production costs are too high to earn 4 percent on this investment, even with no land costs. If we pay anything at all for land under these conditions the expectation value would be even lower, indicating that we cannot hope to earn 4 percent with these costs and incomes.

How Much Can Be Spent for Stand Establishment?

Using this same method, we can estimate how much can be spent to establish a red pine stand and still maintain a specified return on the investment. Since establishment costs are an investment for only one rotation, the present net value for one rotation excluding these costs will give an estimate of the maximum allowable establishment cost.

Land, release, pruning, and annual costs amounted to $34.76 present value per acre in our example. Subtracting this from the present value of incomes gives a present net value of $68.02. Establishment costs could be as high as $68 per acre, and this investment would still pay 3-percent compound interest. Any higher cost than this would reduce the rate of return below 3 percent. If land and annual costs were the only costs considered, the present net value would have been $83.98, indicating that the present value of combined establishment and stand improvement costs could not exceed this amount without reducing the rate of return below 3 percent.

How Much Can Be Spent for Annual Costs?

Leaving annual costs out of the example gives a present net value of $27.42. The present value of annual costs for one rotation could be as high as this amount and still earn a 3-percent return. The present value of annual costs is given by the expression:

Present value of annual costs —

$$= c \frac{(1+p)^n - 1}{p(1+p)^n}$$

Setting this equal to $27.42 and solving for the annual costs *c*:

$$c \frac{(1.03)^{95} - 1}{.03(1.03)^{95}} = \$27.42$$

$$31.32c = \$27.42$$

$$c = \$\ 0.88$$

Annual costs could be as high as $0.88 per acre with the other costs and incomes shown in the example, and the investment would still pay a 3-percent return. These annual costs could be split up in any way among taxes, maintenance, or general administrative expenses. For example, with a $0.30 administrative and maintenance expense this property could support at most an annual tax of $0.58 per acre and still maintain a 3-percent return.

What Is the Cost of Producing Stumpage?

Many investors want to know how much it will cost per cord or per thousand board feet to grow pulpwood or sawtimber in red pine stands. For example, a pulp and paper company can use this information to compare the cost of growing its own wood with what it may have to pay to get this wood elsewhere. The cost of producing stumpage can be estimated if the volume yields and all costs of production are known and the cost of capital (the discount rate) is fixed.

If incomes and costs are discounted, using the fixed rate of return, then when the stand is just earning this rate of return the present value of

incomes (PVI) = the present value of costs (PVC). When only one product such as cordwood is produced, PVI is found by multiplying the price per cord (P_c) by the cordwood expectation value index (EVI_c):

$$PVI = (P_c)\ (EVI_c)$$

Setting this equal to PVC gives the expression:

$$(P_c)\ (EVI_c) = PVC$$

$$\text{Or: } P_c = \frac{PVC}{EVI_c}$$

Dividing the present value of costs by the expectation value index for cordwood gives the average price per cord that will make PVI = PVC, the price that will just return the fixed rate of return on the capital invested in growing this timber. It is also the average cost per cord of growing timber if all invested capital must earn the fixed rate of return. We will refer to it as the cost-price of producing timber.

In the example used before, a red pine stand on site index 55 with 800 trees and 120 square feet at age 25, thinned to 90 square feet with a fixed 3-percent rate of return (discount rate), the EVI if only cordwood is grown would be 14.94 (table 11). The present value of the costs listed in exhibit 3 would be $84.34 with a rotation of 85 years. Under these conditions the cost-price of producing cordwood (P_c) would be $84.34 divided by 14.94, or $5.65 per cord.

Finding cost-prices when both cordwood and sawtimber are produced jointly is more difficult, because we must find both simultaneously. Setting the PVI equal to the PVC we would have:

$$(P_c)\ (EVI_c) + (P_s)\ (EVI_s) = PVC$$

Using our original example of a stand on site index 55 with a fixed 3-percent rate of return and the EVI's and costs listed in exhibit 3, we get:

$$(P_c)\ (7.59) + (P_s)\ (4.38) = \$84.76$$

Because there are two unknown prices, there is no unique solution to this equation. To calculate these prices, either we must set one of the prices and then calculate the other, or we must decide how large one price is to be in terms of the other. In the previous example the cordwood price of $2 per cord was one-tenth the sawtimber price of $20 per thousand board feet:

$$P_c = 0.1\ P_s$$

If this arbitrary price ratio of 1 to 10 is accepted and substituted into the previous equation, stumpage prices can be estimated:

$$7.59\ (0.1\ P_s) + 4.38\ P_s = \$84.76$$

$$5.14\ P_s = \$84.76$$

$$P_s = \$16.49 \text{ per M board feet}$$

$$P_c = 0.1\ (\$16.49)$$

$$P_c = \$1.65 \text{ per cord}$$

If the timber from this stand, grown at the costs given in exhibit 3, can be sold for $16.50 per thousand board feet and $1.65 per cord, then this investment will pay 3 percent on invested capital. This is the cost-price of growing red pine stumpage under these conditions.

Where two products such as these are produced jointly, the allocation of costs to determine selling prices is somewhat arbitrary. The 10 to 1 price ratio in the above example was based on unpublished records of stumpage sales by National Forests in northern Minnesota. Any other suitable ratio could have been used; or the price of either cordwood or sawtimber could have been fixed. If so, then a different set of prices would have been obtained, but the total present value of incomes would still have to equal the present value of costs to earn 3 percent on the investment.

X. INVESTMENT RETURNS FOR SELECTED COSTS AND PRICES

We have seen how present values of incomes and costs can be estimated and used to answer questions about growing red pine as an investment. Although many investors will want to work out for themselves the investment returns they can expect from growing red pine under their own conditions, some may be satisfied with approximations for a range of cost and price levels. Graphs of present values of costs and incomes and tables of rates of return are presented in this section for the stumpage prices and costs shown in exhibit 11.

Other assumptions made for these examples are that:

1. Stands on site index 45 have 800 trees and 90 square feet per acre before thinning at age 25.
2. Stands on site index 60 have 800 trees and 120 square feet per acre before thinning at age 25.
3. Stands are to be thinned to 90 square feet every 10 years.
4. Stands will produce the cordwood and sawtimber yields given in the volume tables underlying this analysis.
5. All merchantable cordwood and sawtimber cut can be sold at the prices indicated, which are net of timber sale costs.
6. The establishment costs are the present value for one rotation of all future costs of establishing and maintaining red pine stands.

Exhibits 12-15 can be used to determine the present values of costs and incomes for any specified interest rate. For example, on site index 60 when the price per thousand board feet is 10 times the price per cord (exhibit 13), the present value of a high income level at a 4-percent interest rate is $92 per acre. The present value of medium costs is only $52 per acre, so the income exceeds costs by $40 per acre. At 5 percent, the present value of incomes would be $51 per acre, only slightly more than the present value of costs. At 6 percent, the $30 present value of incomes is considerably less than the $48 present value of costs.

Notice that for this combination of high incomes and medium costs the present value of incomes is higher than costs at any rate below 5 percent, and the investment is financially attractive. At any rate above 5 percent, costs exceed incomes, and the investment is not attractive. The interest rate at which discounted costs equal discounted incomes, where the cost line crosses the income line, is the rate of return on that particular investment, 5.0 percent in this example.

Present values of costs and prices other than those specified can be read from the graph by interpolation if they are within the range covered.

For convenience, rates of return for all combinations of the four cost-price levels are given in exhibits 16 and 17. When the price per thousand board feet is 10 times the price per cord, and the site index is 45, the rate of return on invested capital varies from less than 2.0 percent for very high costs and low incomes to 5.4 percent for low

EXHIBIT 11. — Costs and prices assumed for several common investment situations in red pine stands.

Item	Cost-price level			
	Low	Medium	High	Very high
Costs per acre				
Establishment	20.00	40.00	60.00	80.00
Annual	.25	.50	.75	1.00
Prices (10 to 1 ratio)				
Per thousand board feet	10.00	20.00	30.00	40.00
Per cord	1.00	2.00	3.00	4.00
Prices (10 to 2 ratio)				
Per thousand board feet	10.00	20.00	30.00	40.00
Per cord	2.00	4.00	6.00	8.00

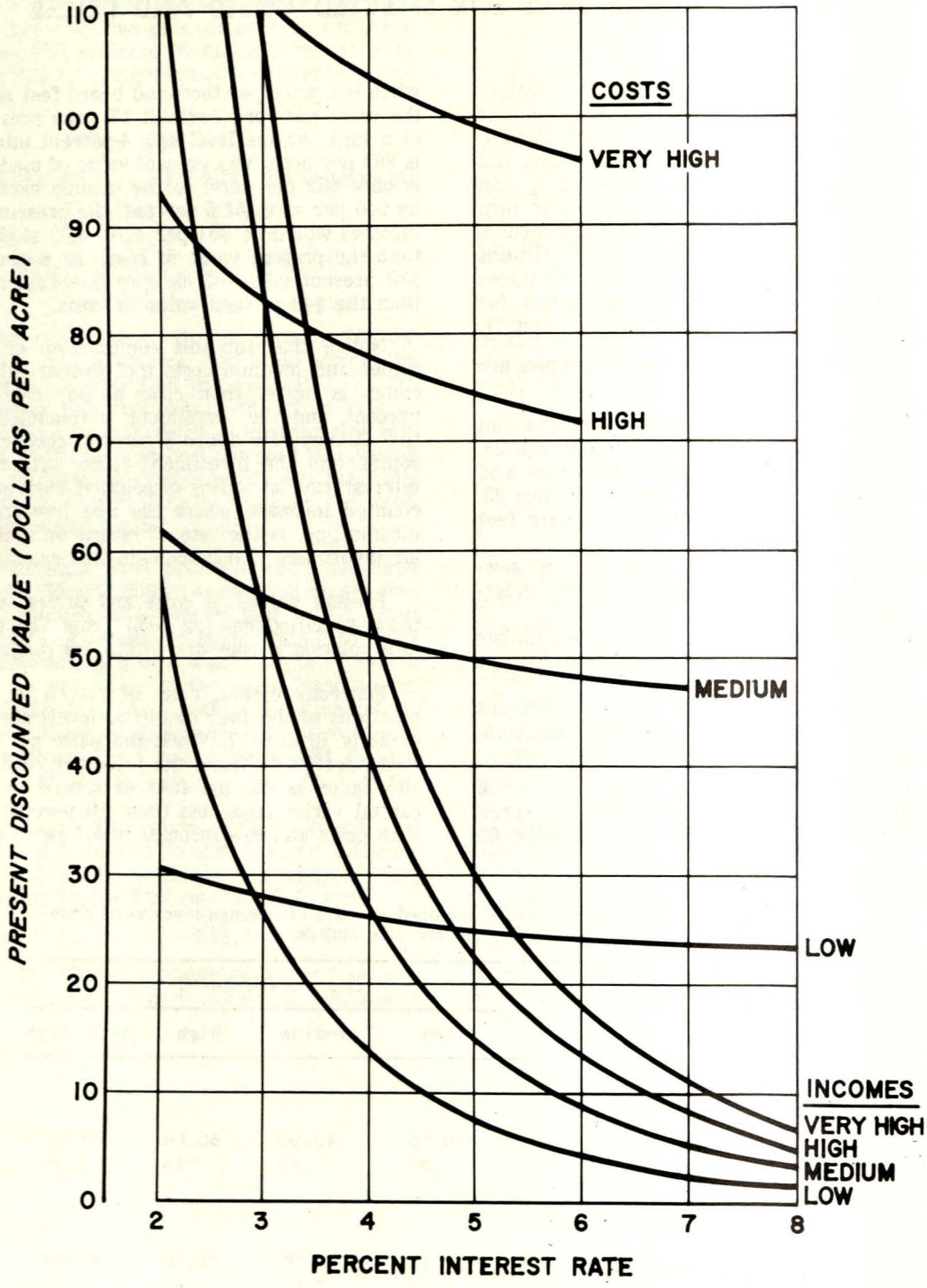

EXHIBIT 12. — Interest rate earned from growing red pine timber on site index 45 when stumpage prices per thousand board feet are 10 times the price per cord. Stand has 800 trees and 90 square feet per acre before thinning at age 25 and is to be thinned to 90 square feet every 10 years. Prices and costs are as described in exhibit 11.

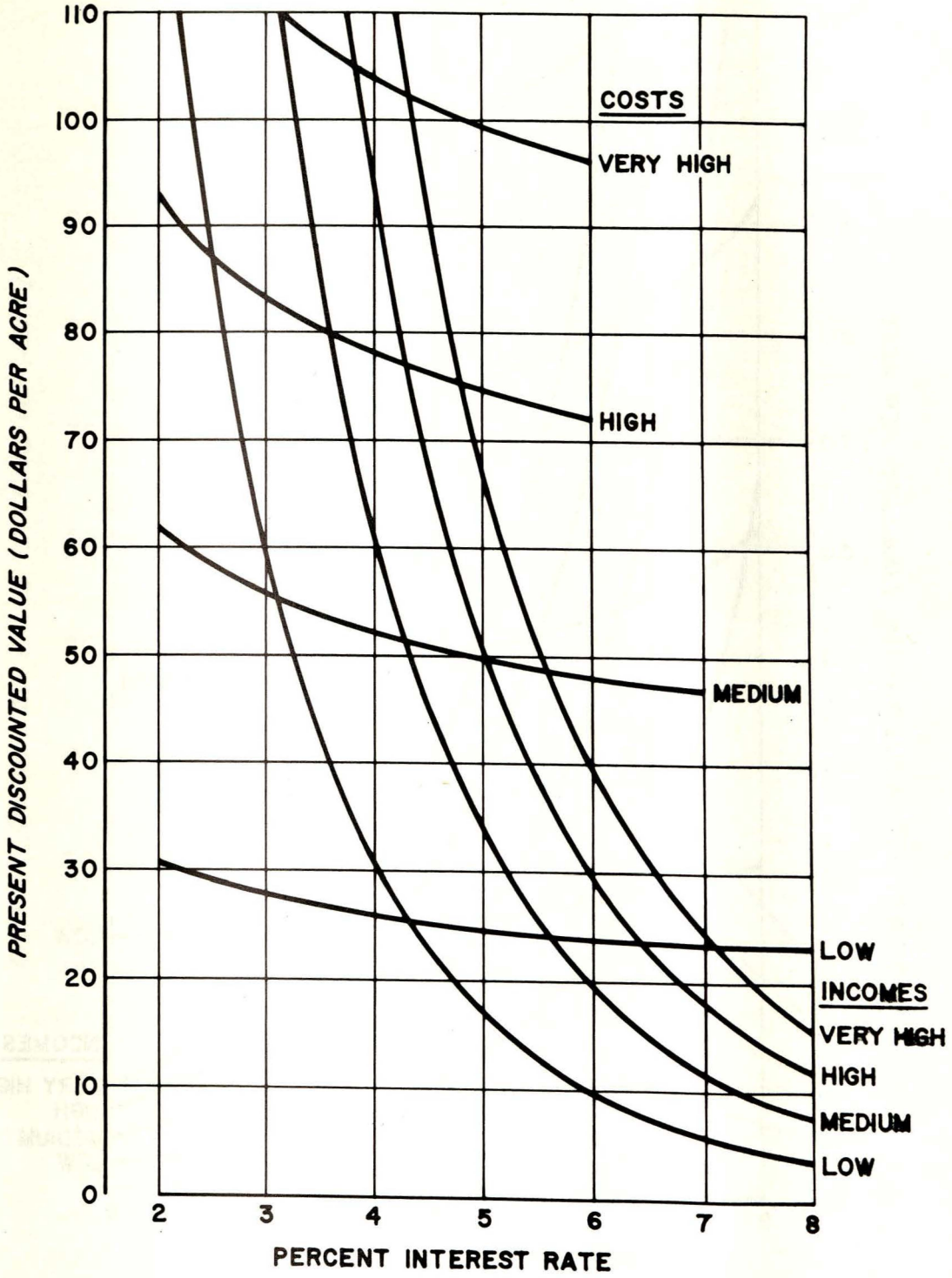

EXHIBIT 13. — Interest rate earned from growing red pine timber on site index 60 when stumpage prices per thousand board feet are 10 times the price per cord. Stand has 800 trees and 120 square feet per acre before thinning at age 25 and is to be thinned to 90 square feet every 10 years. Prices and costs are as described in exhibit 11.

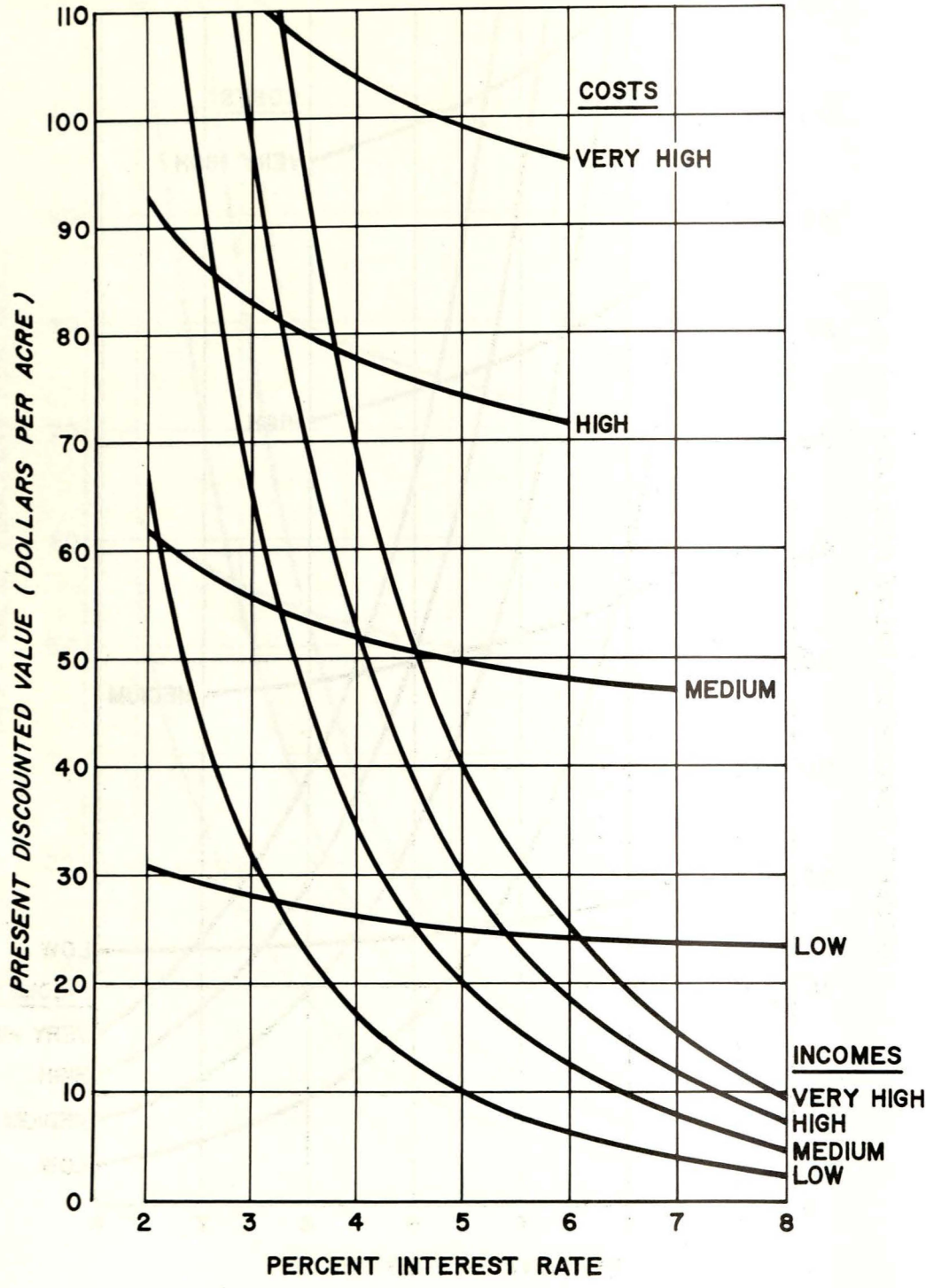

EXHIBIT 14. — Interest rate earned from growing red pine timber on site index 45 when stumpage prices per thousand board feet are 5 times the price per cord. Stand has 800 trees and 90 square feet per acre before thinning at age 25 and is to be thinned to 90 square feet every 10 years. Prices and costs are as described in exhibit 11.

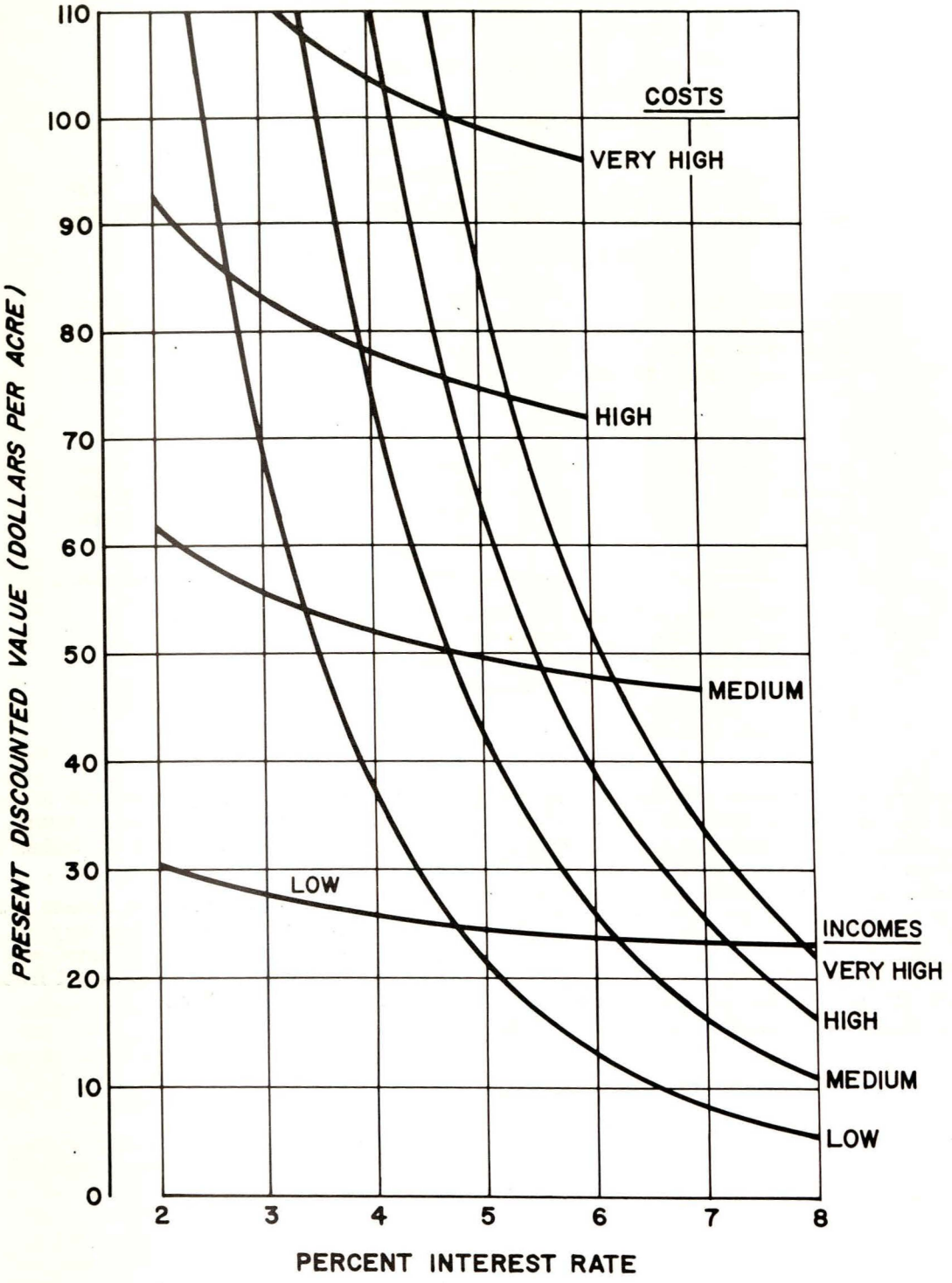

EXHIBIT 15. — Interest rate earned from growing red pine timber on site index 60 when stumpage prices per thousand board feet are 5 times the price per cord. Stand has 800 trees and 120 square feet per acre before thinning at age 25 and is to be thinned to 90 square feet every 10 years. Prices and costs are as described in exhibit 11.

EXHIBIT 16. — Rate of investment return from growing red pine for stated cost and income levels, where stumpage prices per thousand board feet are 10 times the price per cord. [1]

(In percent)

Cost level[2]	Income level[3]			
	Low ($10, $1)	Medium ($20, $2)	High ($30, $3)	Very high ($40, $4)
		Site Index 45		
Low ($20, $.25)	2.9	4.1	4.8	5.4
Medium ($40, $.50)	(4/)	2.9	3.6	4.1
High ($60, $.75)	(4/)	2.3	3.0	3.4
Very high ($80, $1.00)	(4/)	(4/)	2.5	2.9
		Site Index 60		
Low	4.3	5.6	6.4	7.1
Medium	3.1	4.3	5.0	5.6
High	2.5	3.6	4.3	4.8
Very high	2.0	3.1	3.8	4.3

1/ See the assumptions made as to stand conditions and thinning practices and listed in this section of the text.
2/ Establishment and annual costs given in parentheses.
3/ Stumpage prices per thousand board feet and per cord given in parentheses.
4/ Less than 2 percent.

costs and very high incomes (exhibit 16). On site index 60 the rate ranges from 2.0 to 7.1 percent. With a medium level of costs and incomes the rate is 4.3 percent on site index 60 but only 2.9 percent on site index 45. For any given income level, costs can be twice as high on site index 60 as on site index 45, and still the rate of return will be higher on the better site.

Exhibit 17 gives rates of return where the price per thousand board feet is five times the price per cord. Because cordwood is worth more relative to sawtimber, rates of return for each cost-price level combination are higher than they were in exhibit 16.

Although these examples include only a limited range of conditions, they may be useful to those investors who want to know only approximately what return they can expect from growing red pine as an investment.

EXHIBIT 17. — Rate of investment return from growing red pine for stated cost and income levels, where stumpage prices per thousand board feet are five times the price per cord. 1

(In percent)

Cost level 2/	Income level 3/			
	Low ($10, $2)	Medium ($20, $4)	High ($30, $6)	Very high ($40, $8)
		Site Index 45		
Low ($20, $.25)	3.3	4.5	5.4	6.1
Medium ($40, $.50)	2.1	3.3	4.0	4.5
High ($60, $.75)	(4/)	2.6	3.3	3.8
Very high ($80, $1.00)	(4/)	2.1	2.8	3.3
		Site Index 60		
Low	4.7	6.2	7.2	7.9
Medium	3.4	4.7	5.5	6.2
High	2.7	3.9	4.7	5.3
Very high	2.2	3.4	4.1	4.7

1/ See the assumptions made as to stand conditions and thinning practices and listed in this section of the text.
2/ Establishment and annual costs given in parentheses.
3/ Stumpage prices per thousand board feet and per cord given in parentheses.
4/ Less than 2 percent.

XI. SOME CONCLUDING REMARKS

In this Paper forest managers and owners will find tools for estimating investment returns (before taxes) from growing red pine. They are shown how to evaluate quickly and easily the income from the sale of timber together with the costs of growing it, and how to use this information to compare investment alternatives and answer questions about investments in growing red pine.

In a limited space it was not possible to cover all the alternatives considered as background to this study, such as a wider range in numbers of trees per acre, stand density left after thinning, and rotation ages; variations in density throughout the rotation; and stumpage prices that varied with stand characteristics. It was, therefore, necessary to pick out those alternatives that appeared most useful to a wide variety of owners. In so doing, we have limited the choices available to the user. But even those forest managers whose opportunities go beyond the range of choices shown will find useful guides here.

Predictions of income from future stands assume that the yield table volumes used in this analysis will be obtained from average stands of red pine. Those who own large areas of forest land may want to make adjustments for catastrophic losses. If they can estimate the extent of such losses, they can increase per-acre costs to reflect these losses as was shown here for establishment costs, or reduce the expectation value indexes to reflect lower average yields per acre. The forest manager who uses these data to estimate investment returns from small tracts should keep in mind that yields from any one stand may vary considerably from the average yields on which these evaluations have been based.

The rates of return shown for the few examples given in this paper are low, the highest being 7.9 percent on site index 60 for the favorable combination of very high prices and low costs (exhibit 17). With the present high costs and low stumpage

prices encountered by many land owners in the Lake States, growing red pine on medium or poor sites usually is not financially attractive when compared with other investment alternatives. Better sites, with lower costs and higher prices, will show higher rates of return. For example, on site-index-65 land, with medium costs and with prices of $30 per thousand board feet, the rate of return would be close to 6 percent.

The owner who grows red pine on the best sites available, who uses every available technique to reduce his costs (especially his initial costs of establishment), and who establishes stands on land close to markets so that he will get the highest prices for the products he expects to grow, is in the best position to earn a high rate of return on his investment. Using the information in this paper and following the method outlined here, each owner can estimate for himself what returns he can expect from growing red pine as an investment in the Lake States. Although an investment analysis such as this supplies only part of the information a forest manager needs to help him decide among investments, this information is of great importance so long as our wants and production alternatives are many, and our resources are few.

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[1] *Research Paper LS-21 is the final one in the Lake States Station series. Because of a recent reorganization in the U.S. Forest Service that involved a change in research territories, the Station's name was changed to North Central Forest Experiment Station, and a new series, called U.S. Forest Service Research Paper NC——, was begun in 1966.*

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